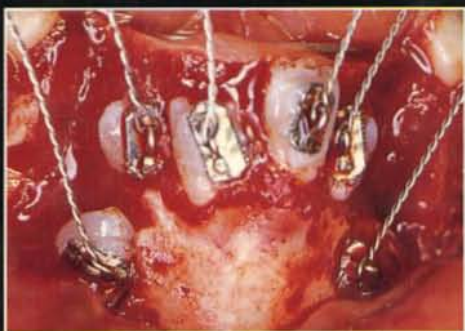


The Orthodontic Treatment of Impacted Teeth

Adrian Becker



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The Orthodontic Treatment of Impacted Teeth

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PREFACE

There can be little question that the treatment of impacted teeth has caught the imagination of many in the dental profession. The challenge has, over the years, been taken up by the general practitioner and by a number of dental specialists, including the paedodontist, the periodontist, the orthodontist and, most of all, the oral and maxillofacial surgeon. Each of these professionals has much "input" to offer in the resolution of the immediate problem and each is able to show some fine results. However, no single individual on this specialist list can completely and successfully treat more than a few of these cases, without the assistance of one or more of others of his/her colleagues on that list. Thus, the type of treatment prescribed may depend upon which of these dental specialists sees the patient first and the level of his/her experience with the problem in his/her field. Such treatment may involve surgical exposure and packing, it may involve orthodontic space opening, perhaps auto-transplantation, or a surgical dentoalveolar set-down procedure, or even just an abnormally angulated prosthetic crown reconstruction.

Experience has come to show that the orthodontic/surgical modality has the potential to achieve the most satisfactory results, in the long term. Despite this, many orthodontists have ignored or abrogated their respon-

sibility towards the subject of impacted teeth to others, accounting for the popularity of other modalities of treatment. The subject has become something of a Cinderella of dentistry.

Within the orthodontic/surgical modality, much room exists for debate as to what should be done first and to what lengths each of the two specialties represented should go in the zealous pursuit of its allotted portion of the procedure. The literature offers scant information and guidance to resolve these issues, leaving the practitioner to fend for him/herself, with a problem that has ramifications in several different specialist realms.

This book discusses the many aspects of impacted teeth, including their prevalence, aetiology, diagnosis, treatment timing, treatment and prognosis. Since these aspects differ between incisors and canines, and between these and the other teeth, a separate chapter is devoted to each. The material presented is based on the findings of clinical research that has been carried out in Jerusalem by a small group of clinicians, over the past 15 years or so, at the Hebrew University — Hadassah School of Dental Medicine, founded by the Alpha Omega Fraternity and from the gleanings of clinical experience in the treatment of many hundreds of my patients, young and old.

An overall and recommended approach to the treatment of impacted teeth is presented and emphasis is placed on the periodontal prognosis of the results. Among the many other aspects of this book, the intention has been to propose ideas and principles that may be used to resolve even the most difficult impactions, employing orthodontic auxiliaries of many different types and designs. None of these is specific to any particular orthodontic appliance system or treatment "philosophy", notwithstanding the author's own personal preferences, which will become obvious from many of the illustrations. These auxiliaries may be used with equal facility in virtually any appliance system with which the reader may be fluent. The only limitations in the use of these ideas and principles are those imposed on the reader by his/her own imagination and willingness to adapt.

The orthodontic manufacturers' catalogues are replete with the more commonly and routinely used attachments, archwires and auxiliaries, which are offered to the profession with the aim of streamlining the busy practice. These catalogue items have not been tailored to the demands of the clinical issues that are raised in this book. These issues, by their very nature, are exceptional, problematic and often unique, while occurring alongside and in addition to the routine. Among the more common limitations self-imposed by many orthodontists has been the disturbing trend to rely so completely upon the use of preformed and pre-welded attachments that they have forgotten the arts of welding and soldering and no longer carry the necessary modest equipment. This then restricts one's practice to using only what is available and sufficiently commonly used to make it commercially worthwhile for the manufacturer to produce. By consenting to this unhealthy situation, the orthodontist is agreeing to work with "one hand tied behind his/her back" and treatment results will inevitably suffer.

I acknowledge and am grateful for the help given me by several colleagues, in the preparation of this manuscript. An excellent professional relationship has been established and has withstood the test of time, with two senior members of the Department of Oral

and Maxillofacial Surgery at Hadassah, with whom a *modus operandi* has been developed, in the treatment of our patients. Professor Arye Shteyer, Head of the Department and, subsequently, Professor Joshua Lustmann have educated me in the finer points of surgical procedure and care while, at the same time, have demonstrated a respect and understanding of the needs of the orthodontist at the time of surgery. I am grateful to them for their collaboration in the writing of Chapter 3.

Dr Ilana Brin read the original manuscript and made some useful suggestions, which have been included in the text. I am grateful to Dr Alexander Vardimon for his comments regarding the use of magnets and to Dr Tom Weinberger for the discussions that we have had regarding several issues raised in the book. My wife, Sheila, read the earlier manuscripts and made many important recommendations and corrections. More than anyone else, she encouraged me to keep writing during the many months when other and more pressing responsibilities could have been used as justifiable excuses for putting the project aside.

My colleagues, Dr Monica Barzel, Dr Yocheved ben Bassat, Dr Gabi Engel, Dr Doron Harary, Dr Tom Weinberger, Professor Yerucham Zilberman, and my former graduate students Dr Yossi Abed, Dr Dror Eisenbud, Dr Sylvia Geron, Dr Immanuel Gillis, Dr Raffi Romano and Dr Nir Shpack, have provided me with several of the illustrations included here and I am indebted to them.

I am grateful, too, to Ms Alison Campbell, Commissioning Editor at Martin Dunitz Publishers and to Dr Joanna Battagel, Technical Editor, for their constructive and professional critique of the manuscript, which contributed so much to its ultimate format. I also thank Naomi and Dudley Rogg, of the British Hernia Centre, for the computer and office facilities that they placed at my disposal during my short sabbatical in London, in the latter stages of the preparation of the work for publication.

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I am very thankful for their cooperation and for their agreement.

Adrian Becker
Jerusalem

1 GENERAL PRINCIPLES RELATED TO THE DIAGNOSIS AND TREATMENT OF IMPACTED TEETH

CONTENTS • Dental age • Assessing dental age • When is a tooth considered to be impacted? • Impacted teeth and local space loss • Whose problem? • The timing of the surgical intervention • Patient motivation and the orthodontic option

In order to understand what an impacted tooth is and whether and when it should be treated, it is necessary to first define our perception of normal development of the dentition as a whole and the time frame within which it operates.

DENTAL AGE

A patient's growth and development may be faster or slower than average, and we may assess his or her age in line with this development (Krogman, 1968). Thus a child may be relatively tall, so that his morphological age may be considered to be advanced. By studying radiographs of the progress of ossification of the epiphyseal cartilages of the bones in the hands of a young patient (carpal index) and comparing this with average data values for children of the same age, we are in a position to assess the child's skeletal maturity. Similarly, there is a sexual age assessment related to the appearance of primary and secondary sexual features, a mental age assessment (IQ tests), an assessment for behaviour and another to measure a child's self-concept. These indices are used to complement the

chronologic age, which is calculated directly from the birth date, to give further information regarding a particular child's growth and development.

Dental age is another of these parameters, and is a particularly relevant and important assessment, which is used in advising proper orthodontic treatment timing. Schour and Massler (1941), Nolla (1960), Moorrees et al (1962, 1963) and Koyoumdjisky-Kaye et al (1977) have drawn up tables and diagrammatic charts of stages of development of the teeth, from initiation of the calcification process through to the completion of the root apex of each of the teeth, together with the average chronologic ages at which each stage occurs.

Eruption of each of the various groups of teeth is expected at a particular time but this may be influenced by local factors, which may cause premature or delayed eruption, with a wide time-span discrepancy. For this reason, eruption time is an unreliable method of assessing dental age.

With few exceptions, mainly related to frank pathology, root development proceeds in a fairly constant manner – usually regardless of tooth eruption or the fate of the

deciduous predecessor. It therefore follows that the use of tooth development as the basis for dental age assessment, as determined by examination of periapical or panoramic X-rays, is a far more accurate tool.

Thus we may find that a child 11–12 years old has four erupted first permanent molars and all the permanent incisors only, with deciduous canines and molars completing the erupted dentition. Were the practitioner merely to run to the eruption chart, he would note that at this age all the permanent canines and premolars should have erupted and he would conclude that the 12 deciduous teeth are over-retained and should be extracted! However, two possibilities exist in this situation, and the radiographs must be studied carefully to distinguish them from each other.

In the event that the radiographs show the unerupted permanent canines and premolars

having completed most of their expected root length, then the child's dental and chronologic ages coincide (Fig. 1.1). The deciduous teeth have not shed naturally, because of insufficient resorption of their roots. As such, we have to presume that they provide the impediment to the normal eruption of the permanent teeth. Their permanent successors may then strictly be defined as having delayed eruption. Under these circumstances, it would be a logical decision to extract the deciduous teeth, on the grounds that their continued presence defines them as over-retained.

The second possibility is that the radiographs reveal relatively little root development, corresponding more closely perhaps to the picture of the 9-year-old child on the tooth development chart (Fig. 1.2). The child's birth certificate may indicate that he is 12 years of



Figure 1.1

Advanced root development of the canines and premolars, defining these teeth as exhibiting delayed eruption. Extraction of the deciduous teeth is indicated.



Figure 1.2

An 11-year-old patient with root development defining dental age as 9 years. Extraction is contraindicated.

age and this may well be supported by his body size and development and by his intelligence. Nevertheless, his dentition is that of a child 3 years younger, defining his dental age at 9 years. Extraction in these circumstances would be the wrong line of treatment, since it is to be expected that these teeth will shed normally at the appropriate *dental* age, and early extraction may lead to the undesired sequelae that are characteristic of early extraction, performed for any other reason.

From this discussion, we are now in a position to define the terms that we shall use throughout this text. The first refers to a *retained deciduous tooth*, which has a positive connotation and which may be defined as a tooth that remains in place beyond its normal shedding time, owing to absence or retarded development of the permanent successor. By contrast, and with a negative connotation, an *over-retained deciduous tooth* is one whose unerupted permanent successor exhibits a root development in excess of three-quarters of its expected final length (Fig. 1.3).

A *permanent tooth with delayed eruption* is an unerupted tooth whose root is developed in excess of this length and whose spontaneous eruption may, in time, be expected. A tooth that is not expected to erupt in a reasonable time in these circumstances is termed an *impacted tooth*.

Dental age is not assessed with reference to a single tooth only, since some variation is found within the different groups of teeth. An all-round assessment must be made, and only then can a definitive determination be offered. However, in doing this, one should be wary of including the maxillary lateral incisors, the mandibular second premolars and the third molars, whose development is not always in line with that of the remaining teeth (Garn et al, 1963; Sofaer, 1970).

ASSESSING DENTAL AGE

When studying full-mouth periapical radiographs or a panoramic film, there are several criteria that may be used in the estimation of tooth development. The first radiographic



Figure 1.3

The mandibular left second deciduous molar is retained (extraction contraindicated), since the root development of its successor is inadequate for normal eruption. The right maxillary deciduous canine, in contrast, is over-retained (extraction advised), since its long-rooted successor has delayed eruption.

signs of the presence of a tooth are seen shortly after initiation of calcification of the cusp tips. Thereafter, one may attempt to delineate the completed crown formation, various degrees of root formation (usually expressed in fractions), through to the fully closed root apex. By and large, orthodontic-treatment is performed on a relatively older section of the child population, and, as such, the stages of root formation are usually the only factors that remain relevant.

The stage of tooth development that is easiest to define is that relating to the closure of the root apex. For as long as the dental papilla is discernible at the root end, the apex is open and still developing. Once fully closed, the papilla disappears and a continuous lamina dura is seen to intimately follow the root outline. The accuracy with which one may assess fractions of an unmeasurable and merely 'expected' final root length is far less reliable and much more subject to individual observer variation.

Root development of the permanent teeth is completed approximately 2.5–3 years after normal eruption (Nolla, 1960). This allows us to conclude that, at the age of 9 years, the

mandibular incisors (which erupt at age 6) will be the first teeth to exhibit closed apices and that these will usually be closely followed by the four first permanent molars. At 9.5 years, the mandibular lateral incisors will complete, while at 10 and 11 years respectively, the maxillary central and normally developing lateral incisors will be fully formed.

This being so, when presented with a set of radiographs, we may proceed to assess dental age by following a simple line of investigation, which uses the dental age of 9 years as its starting point and then progresses forwards or re-traces its steps backwards, depending upon its findings.

If the mandibular central incisor roots are complete, we may presume the patient is at least 9 years old (dental age), and we may then advance, checking for closed apices of first molars (9–9.5 years), mandibular lateral incisors (9.5 years), maxillary central incisors (10 years), normally developing maxillary lateral incisors (11 years), mandibular canines and first premolars (12–13 years), maxillary first premolars (13–14 years), normally developing second premolars and maxillary canines (14–15 years), and second molars (15 years).

By this method, we may arrive at a tentative diagnosis for dental age, on the basis of the last tooth in this sequence that has a closed apex (Fig. 1.4). It is now important to relate the *actual* development of the remaining teeth in the sequence to their *expected* development that may be derived from the wall chart or from tables that have been presented in the literature. This may then provide corroborative evidence in support of the dental age determination.

When the dental age is less than 9 years, none of the permanent teeth will have completed their root development, and the clinician will have no choice but to rely on an estimation of degree of root development, degree of crown completion and, in the very young, initiation of crown calcification (Fig. 1.5). This is most conveniently done by working backwards from the expected development at age 9 years and comparing the dental development status of the patient with this, beginning with the mandibular central incisors and the first permanent molars. Thus, at dental age 6 years, one would find one-half to two-thirds root length of these teeth, and this could be corroborated by studying the development of the other teeth. At the same



Figure 1.4

Root apices are closed in all first molars, all mandibular and three maxillary incisors, excluding the maxillary left lateral incisor.



Figure 1.5

No closed apices. Dental age assessment 7.5 years.

time, one should expect unerupted maxillary central incisors with one-half root length, mandibular canines with one-third root length, first premolars with one-quarter root length, and so on.

As pointed out earlier, variation occurs, and this may lead to certain apparent contradictions. In such cases, eliminating the maxillary lateral incisors, the mandibular second premolars and the third molars will usually simplify the procedure and contribute to its accuracy, since these teeth are more individually variable compared with the rest of the dentition. Additionally, unusually small teeth, coniform premolars and mandibular incisors, and peg-shaped lateral incisors are most often to be seen developing very much later (sometimes as much as 3 or 4 years later), and should not be included in the overall estimation. One may then present a determination for the dentition as a whole, with the added notation that an individual tooth may have a much lower dental age.

We may occasionally examine a 14-year-old patient who has a complete permanent dentition, including the second molars, with the exception that a mandibular second deciduous molar is present. The radiographs (Fig. 1.6) show the apices of the first molars, central and lateral incisors, mandibular canines and premolars to be closed, while the maxillary canines and the second molars are almost closed. However, the unerupted mandibular

second premolar has an open root apex and development equivalent to about half its eventual length. On the basis of the information gathered, we may assess the dental age of the dentition as a whole to be 14 years. At the same time, we should have to note that the dental age of the unerupted second premolar was approximately 10 years. Having made this determination, we may now confidently say that the second premolar, individually, does not exhibit delayed eruption and the deciduous second molar is not over-retained, in the terminology used here. Accordingly, it would not be appropriate to extract the deciduous tooth at this time, but to wait at least a further 2 years, at which time the tooth may be expected to shed normally.

To summarize this discussion, it is essential to differentiate between four different conditions that may exist when we encounter a dentition that includes certain deciduous teeth, inconsistent with the patient's chronologic age. Because the ensuing classification of these conditions is treatment oriented, the labelling of a patient within one of these groupings indicates the treatment that is required.

- 1 *A late-developing dentition.* The dental age of the patient lags behind the chronologic age, as witnessed radiographically by less root formation than is to be expected at a given age, in the entire dentition. Typically, this will be evident clinically by the continued and symmetrical presence of all the deciduous molars and canines on each side of each jaw. Extraction of deciduous teeth is contraindicated at this time.
- 2 *Over-retained deciduous teeth.* The dental age of the patient may be positively correlated with the chronologic age, but the radiograph shows an individual permanent tooth or teeth with well-developed roots, which remain unerupted. This tends to be localized in a single area and may be due to an ectopic siting of the permanent tooth bud, which has stimulated the resorption of only a portion of the root of its deciduous predecessor, but



Figure 1.6

A late-developing left mandibular second premolar. (Courtesy of Dr M Barzel.)

shedding has not occurred because of the persistence of the remaining part of the root or of a second and unresorbed root. Nevertheless, the condition may occasionally be found symmetrically in a single dental arch or in both arches. Extraction of the over-retained teeth is indicated.

- 3 *A normal dental age, with single or multiple late-developing permanent teeth.* This condition is commonly found in relation to the maxillary lateral incisor and the mandibular second premolar teeth, and extraction of the deciduous predecessor is to be avoided.
- 4 *A combination of the above.* Sometimes one may see features of each of the above three alternatives in a single dentition.

The importance of interpreting the differential diagnosis for a given patient cannot be overemphasized, since it has far-reaching effects on all the aspects of diagnosis, treatment planning and treatment timing for cases with impacted teeth.

WHEN IS A TOOTH CONSIDERED TO BE IMPACTED?

From the work of Grøn (1962), we learn that under normal circumstances a tooth erupts with a developing root and with approximately three-quarters of its final root length. The mandibular central incisors and first molars have marginally less root development and the mandibular canines and second molars marginally more when they erupt. We may therefore take this as a diagnostic baseline from which to assess the eruption of teeth in general. Thus, should an erupted tooth have less root development (Fig. 1.7), it would be appropriate to label it as *prematurely erupted*. This will usually be the consequence of early loss of a deciduous tooth, particularly one whose extraction was dictated by deep caries, with resultant periapical pathology.

At the opposite end of the scale, we find the unerupted tooth that exhibits a more completely developed root. The normal eruption process of this tooth must be presumed to

have been impeded by one of several aetiological possibilities. These include such factors as a failure of resorption of the roots of a deciduous tooth, an abnormal eruptive path, a supernumerary tooth, dental crowding or a disturbance in the eruption mechanism of the tooth. However, obstruction may also result from a thickened post-extraction or post-trauma repair of the mucosa (Figs 1.8a, b).

Not infrequently, and particularly in the mandibular premolar region, there may be a history of very early extraction of one or both deciduous molars. Delayed or non-eruption of the premolars will occur, owing to a thickened mucosa overlying the teeth. It may be possible to palpate these teeth, their distinct outline being clearly seen bulging the gum for a period of year or more, although eruption may not occur.

IMPACTED TEETH AND LOCAL SPACE LOSS

A time lapse exists between the performance of a surgical procedure to remove the cause of an impaction and the full eruption of the impacted tooth into its place in the dental arch. The extent of this time span is depen-



Figure 1.7

The left mandibular premolars are prematurely erupted, with insufficient root development.



(a)



(b)

Figure 1.8

(a) The right mandibular second premolar was extracted at age 8.5 years. (b) Seen at age 11, the root of the unerupted first premolar is almost completed.

dant on several factors, such as the initial distance between the tooth and the occlusal plane, the stage of the development of the particular tooth, the age of the patient, and the manner in which hard and soft tissue may be laid down in the healing wound. During this time period, therefore, local changes in the erupted dentition may occur as a result of the break in the integrity of the dental arch caused by the surgical procedure, such as space loss and tipping of the adjacent erupted

teeth. This intervention is no less susceptible to the drifting of neighbouring teeth than is any other factor that may produce interproximal loss of dental tissue.

With an odontome or supernumerary tooth in the path of an unerupted permanent tooth, vertical (and sometimes mesial or distal or buccal or lingual) displacement of the permanent tooth is likely to be considerable. It would be convenient if the removal of the space-occupying body could be performed, leaving the deciduous teeth intact, since the deciduous tooth would maintain arch integrity during the extended period of time needed for the permanent tooth to erupt normally. Unfortunately, often, in order to gain access to perform the desired surgery, one or more deciduous teeth need to be extracted. This being so, and having regard for the long distance that the displaced permanent tooth has to travel, space maintenance should be regarded as essential in most cases. It should be the first orthodontic procedure to be considered in these cases and it should be retained until full eruption has occurred.

Impacted teeth are often associated with a lack of space in the immediate area. This is frequently due to the drifting of adjacent teeth, although crowding of the dentition in general may be the prime cause. In such cases, the spontaneous eruption of an impacted tooth is unlikely to occur unless adequate or, preferably, excessive space is provided. It would be convenient if the excision of the associated pathologic entity could be comfortably delayed until this time, to bring about the desired eruption and to permit this corrective treatment to be attempted when the root development of the unerupted tooth is adequate. However, the surgeon will insist on removing most forms of pathology as soon as a tentative diagnosis is reached, in order to obtain examinable biopsy material for the establishment of a definitive diagnosis. Odontomes and supernumerary teeth are generally considered to be exceptions to this rule, and the timing of their removal may be more leisurely considered.

WHOSE PROBLEM?

Patients do not go to their dentist complaining of an impacted tooth. They are frequently unaware that this abnormality exists, since there is no pain, discomfort or swelling. Neither is it obvious to the layman that there is a missing tooth, since the deciduous predecessor is usually retained. The vast majority of impacted teeth come to light by chance, in routine dental examination, and are not the result of a patient's direct complaint. As a general rule, it is the paedodontist or general dental practitioner who, during a routine dental examination, discovers and records the existence of an over-retained deciduous tooth. A periapical radiograph will then confirm the diagnosis.

There are two principal exceptions where an abnormal appearance may be the reason why the patient seeks professional advice. The first usually brings the patient to the office at the age of 8–10 years, when a single maxillary central incisor will have erupted a year or so earlier and the parent points out that the erupting lateral incisor of the opposite side has not left enough space for the expected eruption of the second central incisor (Fig. 1.9). Often, the deciduous central incisor is retained. In this situation, the parent has recognized abnormality, but will not generally have the technical understanding to suggest the possibility of impaction of the unerupted central incisor.



Figure 1.9

Unerupted right maxillary central incisor with space loss.

The second exception occurs with a 14–15-year-old patient who requests the restoration of an unsightly carious lesion on a retained maxillary deciduous canine. Generally speaking, the patient will be unaware that this is not a permanent tooth, and it will require suitable professional advice to point out that restoration is probably not the appropriate line of treatment, rather extraction and the resolution of the impaction of the permanent canine.

A very small percentage of cases may be seen initially by their general dental practitioner because of symptoms related to relatively rare complications of impacted teeth. Among these symptoms are mobility or migration of adjacent teeth (due to root resorption), painless bony expansion (dentigerous or radicular cyst), or perhaps pain and/or discharge (infected cyst, with communication to the oral cavity) (Shafer et al, 1983).

Initially, the practitioner should ascertain whether there is a good chance that resolution will be spontaneous, once the aetiological factor has been removed, or whether active appliance therapy will be needed. To be in a position to do this, the exact position, long-axis angulation and rotational status of the tooth have to be accurately visualized and an assessment of space in the arch must be made. Following this initial assessment, the paedodontist or general dental practitioner now has to decide who should treat the problem.

Many general practitioners will prefer not to accept responsibility for the case, and will refer the patient to an oral and maxillofacial surgeon, on the basis that surgery will be needed. Many surgeons will agree that the problem is essentially surgical in nature, and will proceed to remove retained deciduous teeth, clear away other possible aetiological factors, such as supernumerary teeth, odontomes, cysts and tumours, and will also expose the impacted permanent tooth. If the impacted tooth is buccally located, the surgical flap may be apically repositioned, to prevent primary closure and to maintain subsequent visual contact with the impacted tooth after healing has occurred. This will have the effect of encouraging eruption in

many cases. Until healing (by 'secondary intention') has occurred, the wound will usually be packed with iodoform gauze impregnated with Whitehead's varnish, over a period of a few weeks. Careful placement and wedging of the pack between an impacted tooth and its neighbour is used by surgeons to help free the tooth to erupt naturally, when the pack is later removed. Often, in more difficult impactions, wider surgical exposure is undertaken, including fairly radical bone resection, both around the crown and down to the CEJ, with complete removal of the dental follicle.

Following a period of many months and (for some more awkwardly positioned teeth) sometimes extending into years, the surgeon will usually then follow up the spontaneous eruption of the impacted tooth until it reaches the occlusal level. If, at that time, alignment is poor or the tooth still has not erupted, the patient will be referred to the orthodontist.

The paedodontist or general dental practitioner may alternatively and preferably refer the patient directly to an orthodontist. Certainly, the orthodontist cannot directly influence the position of the impacted tooth until appropriate access has been provided surgically and an attachment has been placed on the tooth. Nevertheless, with proper planning and management, including the referral for surgical exposure at the appropriate stage in the treatment, a much higher level of quality care may be provided and in a very much shorter time frame. This will be discussed in the ensuing chapters of this book.

THE TIMING OF THE SURGICAL INTERVENTION

From the above discussion, we see that the timing and nature of the surgical procedure are determined by the degree of development of the teeth concerned at the time of initial diagnosis. At an early stage, a radiographic survey of a very young child may reveal pathology, such as a supernumerary tooth, an odontome, a cyst or benign tumour, that appears likely to prevent



Figure 1.10

A midline supernumerary tooth (mesiodens) discovered in routine periapical radiographic view of the maxillary incisor area.

the normal and spontaneous eruption of a neighbouring tooth.

At this stage, from every point of view, it would be inappropriate to expose the crown of an immature tooth. In the first place, one would not want to encourage the tooth to erupt before an adequate (half to two-thirds) root length had been produced. Secondly, at this early stage of its development, the tooth cannot be considered as impacted, and, given time and freedom to manoeuvre, will probably erupt by itself. Early exposure risks the possibility of damage to the crown and to the subsequent root development of the tooth.

Nevertheless, with the discovery of the pathological condition (Fig. 1.10), the potential for impaction exists, and leaving the condition untreated will worsen the prognosis. Accordingly, removal of the pathological entity, without disturbing the adjacent permanent teeth or their follicular crypts, should be the aim of any treatment at that time. It may then reasonably be expected that normal development and eruption will occur in the fullness of time. Whilst this is an obviously desirable course of action, access to the targeted area may be thwarted by the presence and closeness of adjacent developing structures, and delay may still be advised.



Figure 1.11

The panoramic radiograph shows erupted maxillary lateral incisors and over-retained deciduous central incisors. The unerupted central incisors may be seen superiorly to the two unerupted supernumerary teeth. (Courtesy of Dr I Gillis.)

The second scenario occurs when the condition is only discovered much later. In this case (Fig. 1.11), the permanent teeth may justifiably be defined as impacted, and the aims of surgical treatment become twofold: first, to eliminate the pathology, and then to create optimal conditions for the eruption of the permanent tooth, which is already late. This will usually involve exposure of the crown of the tooth. For many teeth, given adequate space in the dental arch and little or no displacement of the impacted tooth, spontaneous eruption may be expected (DiBiase, 1971; Mitchell and Bennett, 1992). As we shall see in subsequent chapters, there are several situations and tooth types where this may not occur, or it may not occur in a reasonable time frame, often because of severe displacement of the affected tooth. For these cases, the natural eruptive potential of the tooth is supplemented and, if necessary, diverted mechanically, with the use of an orthodontic appliance.

PATIENT MOTIVATION AND THE ORTHODONTIC OPTION

Angle's Class II malocclusion is present in between one-fifth and one-quarter of the child population in most countries of the western world (Massler and Frankel, 1951; Brin et al,

1986). However, even a cursory analysis of the patient load of any given orthodontic practice will reveal around three-quarters of the patients being treated for this malocclusion. The reason for this has to do with the fact that a patient's appearance is adversely affected to a greater extent by this condition than by most others. In other words, appearance plays an inordinately large part in the initiative and motivation on the part of the parent of a young patient to seek treatment.

A significant section of the remaining quarter of the patients in this hypothetical orthodontic practice are being treated for various less unsightly conditions (crowding, single ectopic teeth, open bites or class 3 relationships). This leaves only a few patients in this practice sample who have been referred for strictly health reasons, which may not be obvious to the patient.

Appearance is not a problem for this small group of patients, who will have agreed to orthodontic treatment only after motivation has been evoked by the careful and persuasive explanations of a dentist, orthodontist, periodontist, prosthodontist or oral surgeon, regarding the ills that are otherwise likely to befall them and their dentitions.

Most impactions are symptomless, and, aside from maxillary central incisors, do not usually present an obvious abnormal appearance. Accordingly, motivation for treatment in these cases is minimal, and much time has

to be spent with the patient before he or she agrees to treatment. The story does not end there, since these patients may often require periodic 'pep talks' to maintain their level of cooperation and their resolve to complete the treatment. Many of them will not maintain the required standard of oral hygiene, and, while it is difficult to justify continuing treatment in these circumstances it is just as difficult to remove appliances from a patient in the middle of treatment, when impacted teeth have been partially erupted and large spaces are present in the dental arch. For these reasons, while ambitious and innovative treatment plans may be suggested, it is essential to take the motivation factor into account before advising lengthy and complicated treatment, since the risk of non-completion may be high.

REFERENCES

- Brin I, Becker A, Shalhav M (1986) Position of the maxillary permanent canine in relation to anomalous or missing lateral incisors: a population study. *Eur J Orthod* **8**: 12-16.
- Di Biase DD (1971) The effects of variations in tooth morphology and position on eruption. *Dent Pract Dent Rec* **22**: 95-108.
- Garn SM, Lewis AB, Vicinus JH (1963) Third molar polymorphism and its significance to dental genetics. *J Dent Res* **42**: 1344-63.
- Grøn A-M (1962) Prediction of tooth emergence. *J Dent Res* **41**: 573-85.
- Koyoumdjisky-Kaye E, Baras M, Grover NB (1977) Stages in the emergence of the dentition: an improved classification and its application to Israeli children. *Growth* **41**: 285-96.
- Krogman WM (1968) Biological timing and the dentofacial complex. *J Dent Child* **35**: 175-85.
- Massler M, Frankel JM (1951) Prevalence of malocclusion in children aged 14-18 yrs. *Am J Orthod* **37**: 751-60.
- Mitchell L, Bennett TG (1992) Supernumerary teeth causing delayed eruption - a retrospective study. *Br J Orthod* **19**: 41-6.
- Moorrees CFA, Fanning EA, Grøn A-M, Le Bret L (1962) The timing of orthodontic treatment in relation to tooth formation. *Trans Eur Orthod Soc* **38**: 1-14.
- Moorrees CFA, Fanning EA, Hunt EE Jr (1963) Age variation of formation stages for ten permanent teeth. *J Dent Res* **42**: 1490-502.
- Nolla CM (1960) The development of permanent teeth. *J Dent Child* **27**: 254-66.
- Schour I, Massler M (1941) The development of the human dentition. *J Am Dent Assoc* **28**: 1153-60.
- Shafer WG, Hine MK, Levy BM (1983) *A Textbook of Oral Pathology*, 4th edn. WB Saunders, Philadelphia.
- Sofaer JA (1970) Dental morphologic variation and the Hardy Weinberg law. *J Dent Res* **49**(Suppl): 1505.

2 RADIOGRAPHIC METHODS RELATED TO THE DIAGNOSIS OF IMPACTED TEETH

CONTENTS • Qualitative radiography • Three-dimensional diagnosis of tooth position
• CT scanning

It is not the purpose of this chapter to present a complete manual on dental radiography, but rather to concisely highlight those techniques and methods that are useful in the clinical setting, as it pertains to impacted teeth. The methods offered have two main aims (Seward, 1968; Hunter, 1981). The first relates to the furnishing of qualitative information regarding normal and abnormal conditions that may be associated with unerupted teeth. Thus the different ways of radiologically displaying and recognizing pathological entities, such as supernumerary teeth, enlarged eruption follicles, odontomes, root resorption and other pathological entities, are discussed and compared. The second aim is to describe the various radiological techniques that the clinician may find helpful in accurately pinpointing the position of a clinically invisible, unerupted tooth. The relative merits of these techniques are discussed, and indications for their use are suggested in relation to the different groups of teeth involved.

QUALITATIVE RADIOGRAPHY

Periapical radiographs

The first, simplest and most informative X-ray film is the periapical view. This view is oriented to pass through the minimum of surrounding tissue, in order to give accuracy and quality of resolution. It is generally aimed to be perpendicular to an imaginary plane bisecting the angle between the long axis of an erupted tooth and the film plane, to produce the minimum of distortion. The periapical film is designed to view the tooth itself from the angle of best advantage, without any relation to its position in space.

From this film, it will be immediately obvious if there is an impacted tooth and if its stage of development is similar to that of its erupted antimeres, with at least two-thirds of its root length. The presence and size of a follicle will be obvious, and it will be possible to ascertain crown or root resorption, root pattern and integrity. The presence and description of hard tissue obstruction will be evident, allowing the observer to distinguish connate, incisiform and barrel-shaped supernumeraries, and odontomes of the complex or

compound composite types. Similarly, it will show soft tissue lesions, such as cysts. The great clarity offered by the view is superior to that of other views, and it should always be used as the initial film of a suspected impacted tooth in a radiographic examination. As with any radiographic film, however, the periapical view is only two-dimensional, and gives no information in the bucco-lingual plane; overlapping structures cannot be differentiated as to which is lingual and which buccal.

For this film to give the most advantageous view of the teeth in the maxillary arch and in the mandibular anterior segment, the central ray of the periapical view is oblique, and will vary between 20° and 55° to the occlusal plane (Mason, 1982), depending upon the region to be X-rayed. Given this oblique direction, any attempt to estimate the height of the tooth or its bucco-lingual orientation, without additional information, must fail.

When performing periapical radiography on the posterior teeth in the mandibular arch, however, the most advantageous direction has the central ray very close to the horizontal, and, as such, also offers a true lateral view of these teeth. Thus not only will the observer see the most precise detail of the tooth and its surrounding tissues, but it will also be possible to accurately assess its height in the jaw.

Occlusal radiographs

Mandibular arch

In the mandibular arch, this view is properly executed by tipping the patient's head backwards and pointing the X-ray tube at right-angles to a film, held between the teeth, in the occlusal plane (Fig. 2.1). In the lower canine/premolar region, the occlusal view is a 'true' occlusal view and should depict all the posterior standing teeth in cross-section. As such, it should also provide bucco-lingual positional information on the tooth and any associated structures in a plane at right angles to that seen on the periapical film. Because of the thickness of bone traversed, detail is much poorer, unless there is expansion due to

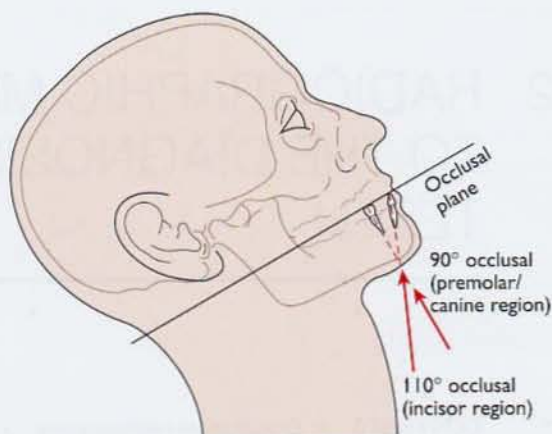


Figure 2.1

Taking a true occlusal view of the lower jaw: for the canine/premolar region and for the incisor region.

a large cyst or bucco-lingually displaced tooth.

In order to produce a true occlusal view in the anterior region of the mandibular arch (Fig. 2.1), the head will need to be tipped back further and the tube pointed at the symphysis menti, at an angle of 110° to the horizontal, in line with the long axes of the incisor teeth. To achieve the same for the molar teeth, the 90° angle to the horizontal will need to be augmented by a 15° medial tilt of the tube, to compensate for the characteristic slight lingual tipping of these teeth (Mason, 1982).

Maxillary arch

Maxillary anterior occlusal. In the maxillary arch, the nose and forehead interfere with the positioning of the X-ray tube, close to the area to be viewed. The best that can be achieved by positioning the tube close to the face is an anterior maxillary occlusal view of the teeth, which is perhaps better described as a high or steeply-angled periapical view (Fig. 2.2). The view will 'shorten' the actual length of the roots, but it will be a far cry from the cross-sectional view that is so easy to achieve in the mandibular arch. Since the central ray passes

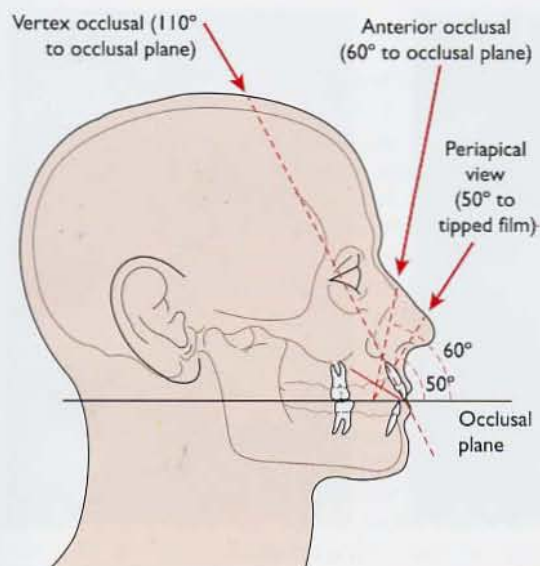


Figure 2.2

A diagram showing incisor inclination, film position and central X-ray beam, differentiating the periapical view, the anterior (oblique) occlusal view and the true vertex occlusal views.

through less thickness of bone, detail is usually good, although not as clear as with the periapical view.

True (vertex) occlusal. A true occlusal view of the anterior maxilla is a view in which the central ray of the X-ray beam runs parallel to the long axis of the central incisors (Fig. 2.2). This is only possible when the cone is placed over the vertex of the skull, to produce the vertex occlusal film. Since the beam has to travel a great distance through the cranium and its contents, the base of the skull and the maxilla, there is a considerable loss in clarity. Recently, an excellent method of producing this view extra-orally has been described (Ong, 1994). In order to avoid the need for a very long exposure, a fast film should be used in a cassette with intensifying screens. For these reasons, the method is not popular.

Nevertheless, in this view (Fig. 2.3), all the



Figure 2.3

A true vertex occlusal film using Ong's projection, showing two palatal canines. The right canine is close to the arch and almost vertical. The crown of the left canine reaches the midline suture, while the root apex is close to the line of the arch.

anterior teeth will be seen in their cross-sectional view as small circles with a tiny concentric circle in the centre, denoting the pulp chamber. No information is available regarding the relative height of the object in the alveolus, and it certainly cannot be used for fine detail. A single tooth that is palatal to the line of the arch will appear within this arc of small circles. If the tooth is at an angle, not parallel to its neighbours, it will show up in its elliptical, oblique cross-section, representing a tilted long axis. If the tooth is horizontal across the palate, its full length will be obvious on this view, together with the exact mesio-distal and bucco-lingual orientation of both the root and the crown, in the horizontal plane (Fig. 2.3).

The difference between the two types of occlusal film may not seem to be very great, but it should be appreciated that, from the vantage point of an anterior occlusal film, the anterior teeth will be foreshortened but will still have appreciable length. In this situation, a high and mesially placed labial canine could give precisely the same picture as a low and mesially placed palatal canine. This could not happen in a vertex occlusal projection.

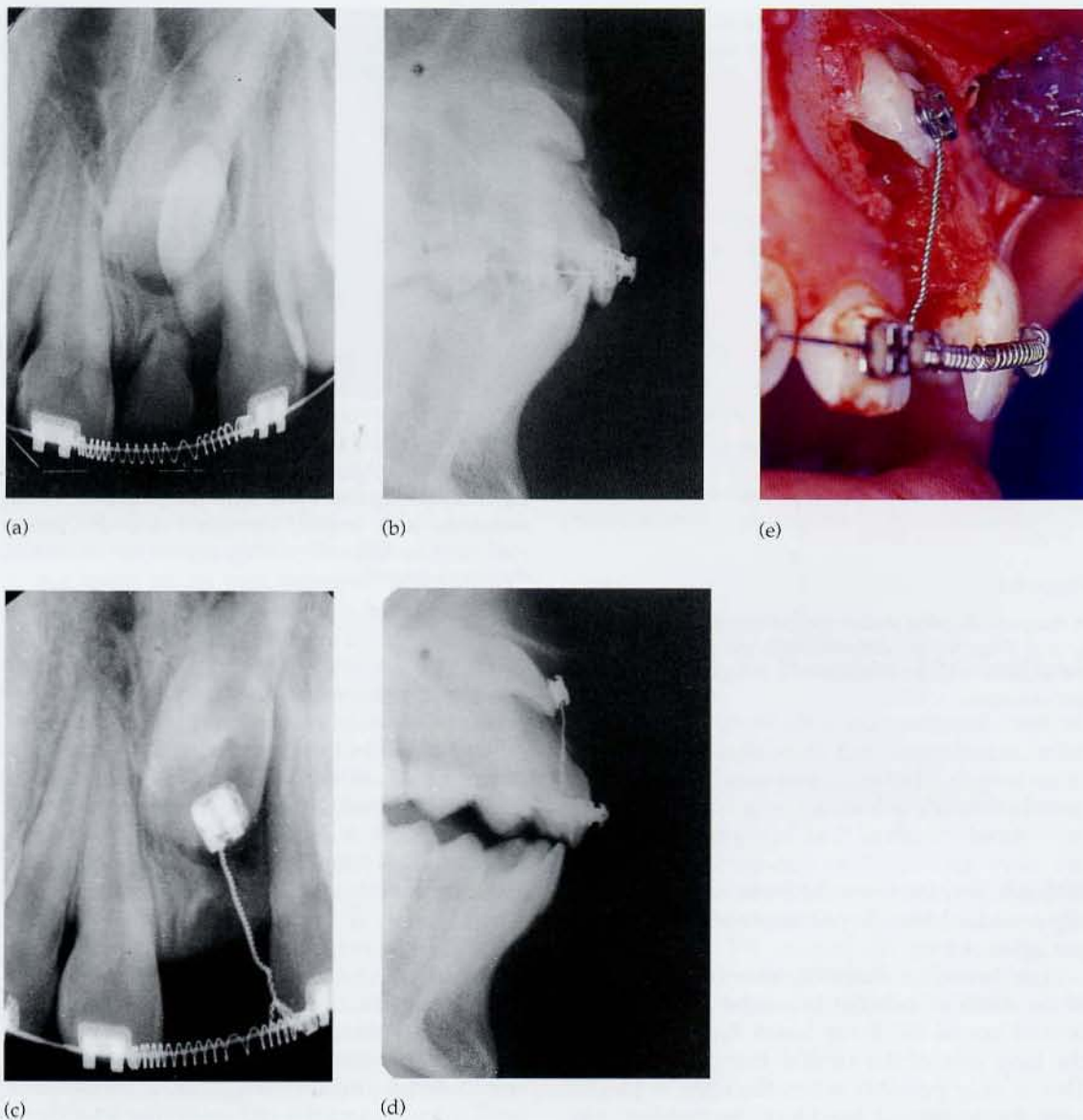


Figure 2.4

(a) The periapical view shows an impacted left maxillary central incisor, due to an inverted unerupted supernumerary tooth. The deciduous tooth is over-retained. Accurate diagnosis of the height of the impacted tooth in the alveolus is not possible from this view. (b) The anterior maxilla, seen on a lateral cephalometric radiograph, shows the high impacted central incisor, facing the labial sulcus; (c) and (d) represent the same views as (a) and (b) after removal of the supernumerary tooth and bracket bonding to the exposed incisor. (Courtesy of Dr D Harary.) (e) A parallel intra-oral photographic view. This film has been laterally inverted to simplify comparison.

Extra-oral radiographs

The panoramic view, while not showing the same degree of detail as a periapical film, has the advantage of simply and quickly offering a good scan of teeth and jaws, from TM joint to TM joint. It is probably true to say that orthodontists are today in general agreement that this film gives the most qualitative information, to act as a starting point from which to proceed to other forms of radiography, in line with the demands of the particular situation in any given case.

True and oblique lateral extra-oral views (Figs 2.4a-e) and the variously angulated oblique occlusal films all provide information that may be used to complement the periapical film, particularly when tooth displacement is severe. However, the use of any oblique film for the accurate localization of a buried tooth may frequently be misleading, be it a single periapical, an occlusal or a lateral jaw film. This being so, two incipient dangers exist. First, as we shall see in later chapters, a surgical procedure may be misdirected and a flap opened on the wrong side of the alveolar process. Secondly, misinterpretation of the tooth's position may lead the operator to assume a very favourable prognosis for biomechanical resolution when, in fact, the tooth may be in a completely intractable position. Thus the choice of treatment will be inappropriate.

THREE-DIMENSIONAL DIAGNOSIS OF TOOTH POSITION

As dentists, we are very used to seeing periapical films of individual teeth, and, provided that the teeth concerned are in the line of the arch, these films have many advantages. However, in this view, the X-ray tube is not directed in the true horizontal, true vertical or true lateral planes. Aside from radiography of the mandibular posterior teeth, the tube is always tipped at an angle to one or more of these planes. This is unimportant for an erupted tooth, since the third dimension is supplied by the direct vision within the

mouth. Thus, while it gives a good two-dimensional representation of the tooth, this view has limited value when visualization of an unerupted tooth is required, in the three planes of space.

PARALLAX METHOD

By following the principles involved in binocular vision, two periapical views of the same object and taken from slightly different angles can provide depth to the flat, two-dimensional picture depicted by each of the films individually (Fig. 2.5). This is of considerable help with distinguishing the buccal or lingual displacement of the canine, which is low down and fairly close to the line of the arch. The procedure is performed in the following manner (Fig. 2.6).

- 1 A periapically sized film is placed in the mouth, with the patient's finger holding it against the palatal aspect of the area where the tooth would normally be situated. The X-ray tube is directed at right-angles to a tangent to the line of the arch at this point, as for any periapical view



Figure 2.5

The left periapical view, oriented for the central incisors, shows the crown of the canine superimposed on the distal half of the central incisor root. The middle film, rotated 30° to the left, shows the canine overlapping only the lateral incisor root. By rotating the central beam a further 30°, superimposition of the canine over the lateral incisor root has been eliminated. The canine is palatally displaced.

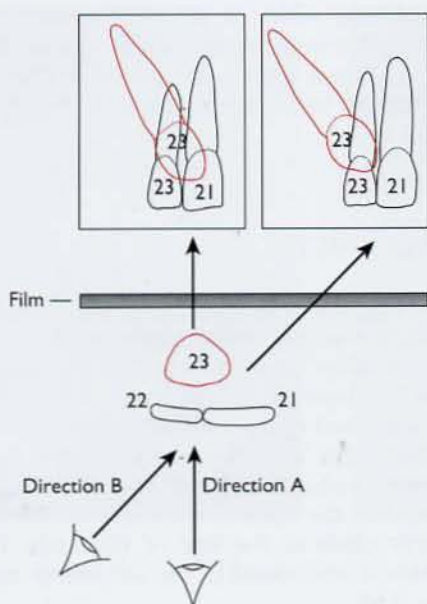


Figure 2.6

A diagrammatic representation of the parallax method. If the observer's eye peers along the axis of the X-ray beam in each case, the image on the film will be easy to reconstruct.

and at the appropriate angle to the horizontal plane.

- 2 A second film is placed in the mouth in the identical position, but on this occasion the X-ray tube is shifted (rotated) mesially or distally round the arch, but held at the same angle to the horizontal plane and directed at the mesially or distally adjacent tooth. To achieve this, the tube should describe between 30° and 45° of an arc of a circle whose centre is somewhere in the middle of the palate.

Let us assume that a right unerupted canine is palatally placed (Fig. 2.6), then this tooth will be close to the middle of the picture obtained in both films. However, in the first picture, where the tube was directed over the designated canine area of the ridge, the lateral incisor root will be on the right. If the canine is also well forward, there will be some overlap of the canine crown and the lateral incisor root. On the second picture, taken from the

front, the right lateral incisor root and the crown of the palatal canine will be in the middle, superimposed on one another to a much greater degree.

Jacobs (1986, 1987) enjoins the observer to use the right eye in place of the X-ray tube and suggests the useful exercise of holding up two fingers vertically at eye level, with one obscuring the other. If the observer now closes this eye and opens the other, his or her new vantage point for inspection will have resulted in a visual separation of the two fingers. Through the left eye, the obscured finger will have 'moved' to the left of the forward finger, to become partially visible. Transferring this to the radiographic context, in the second picture, the tooth furthest from the tube (i.e. the palatal tooth) will 'move' in the same direction that the X-ray tube has travelled from the first exposure.

This method is very useful in cases where there is a minimal height discrepancy between the erupted and unerupted adjacent teeth (Fig. 2.5). However, when the canine is high and the periapical view shows no superimposition of the canine with the roots of the erupted teeth, or where the superimposition is only in the apical area, then the overall picture may be very misleading and a different method of localization should be used. The periapical view is directed from above the occlusal plane and in an oblique downward and medial direction, which distances the palatal canine from the roots of the other teeth and makes it appear higher than the anatomy of the maxilla would allow.

In the incisor region, an unerupted permanent incisor may be associated with one or two supernumerary teeth (mesiodens). The parallax method is insufficiently clear in these cases, because of the presence of two or three hard tissue entities in the bone, superimposed on the outline of the roots of the deciduous teeth and at varying heights in the alveolus.

Radiographic views at right-angles

Radiographic views may be taken at right-angles (Seward, 1968; Hunter, 1981) to one

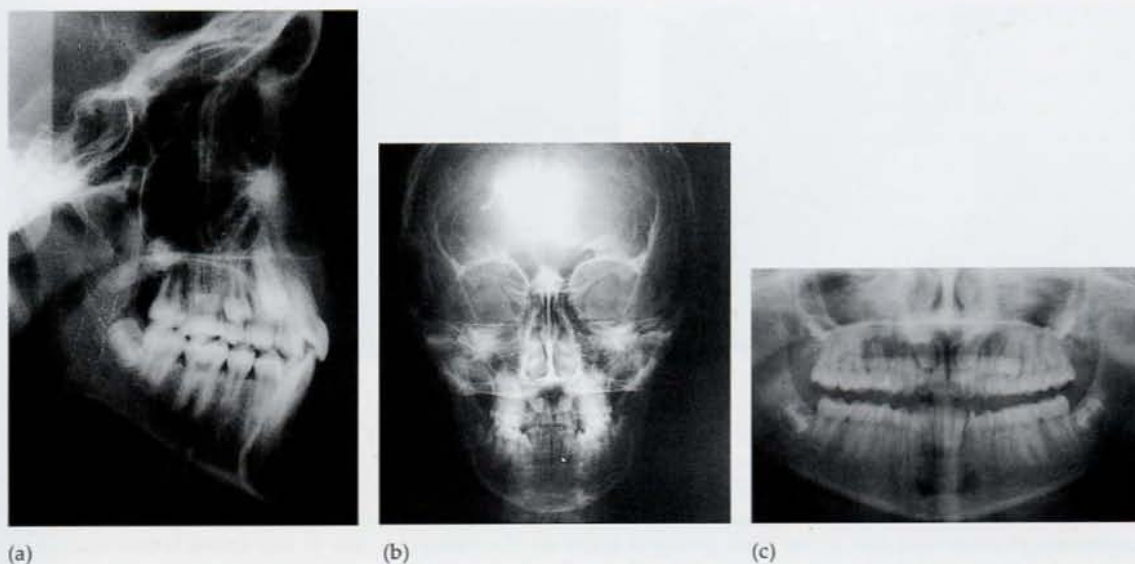


Figure 2.7

(a) The true lateral cephalometric radiograph shows both canines superimposed, at a higher level than the other teeth. Their axial inclination in the antero-posterior plane is favourable, with the crowns and apices apparently normally located. (b) The postero-anterior cephalometric radiograph shows the two canines similarly angulated, with their apices in the line of the arch and the crowns close to the midline. From these two films, we may conclude that the apices are ideally placed and that the long axes of the teeth have a downward, mesial and palatal inclination. (c) The panoramic view of the same patient. The appearance of canines close to the midline is very similar to that seen on the postero-anterior cephalometric radiograph.

another in various ways, but, for the method to be of value, it must be possible to determine the exact orientation in space of both the film and the central ray, by observing other structures on the film. This requirement is very difficult to satisfy when a view is sought at right angles to the periapical view.

Standardization. What is required is the standardization of views within the confines of a strict adherence to the planes of space. A true lateral view (Fig. 2.7a) will give exact information regarding both the antero-posterior and vertical location of an object, relative to other structures that may be seen both on that radiograph and clinically. It will not give any clue to the bucco-lingual (transverse-plane) picture. A true occlusal view will provide positional information in both the antero-posterior and transverse planes, but not the vertical plane. The third possibility is the true postero-anterior view (Figs 2.7b,c), which defines the height (vertical plane) and the

bucco-lingual relationship only. By combining the results of any two of these three films, three-dimensional localization may be accurately determined.

Translating these principles into radiographic practice presents some difficulties. However, these are not insurmountable and, insofar as they present the clinician with accurate positional visualization of the unerupted tooth, they are entirely worthwhile.

In the mandibular posterior area, we have pointed out that the routine periapical radiograph is also a true lateral view, with the X-ray tube pointing at right-angles across the body of the mandible, in the horizontal plane. The height and mesio-distal position of a buried tooth may then be accurately defined. The occlusal radiograph of this area is directed at right angles to the occlusal plane, and adds the bucco-lingual dimension to complete the three-dimensional picture.

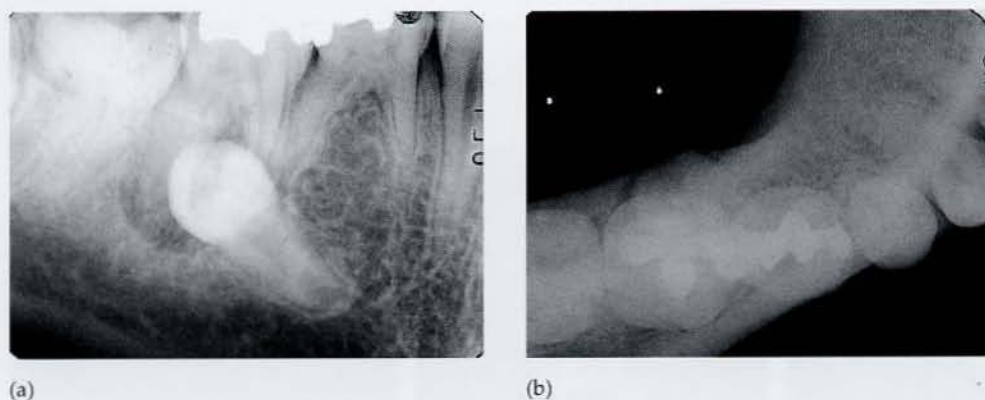


Figure 2.8

The true lateral and true occlusal views, taken together, provide all the information needed for an accurate positional assessment of crown and root in the three planes of space. (a) The periapical view (a true lateral in this case) of an impacted mandibular right second premolar shows the tooth to be tipped distally 60° from the vertical, with its incomplete apex at the correct height and mesio-distal location. (b) The true occlusal view shows the crown of the tooth to be lingual to the molar, and the apex to be in the bucco-lingual line of the arch. The long axis of the tooth, proceeding from its ideally sited apex, may be described as rising at a 30° angle in a distal and lingual direction, to overlap the molar roots on the lingual side.

Accordingly, these two views will provide accurate localization of the position of unerupted teeth in this area (Fig. 2.8).

For most orthodontic cases, the lateral cephalometric radiograph is an essential prerequisite and, aside from the routine measurement of angles and planes, this film should also be used to gather valuable information regarding the location of unerupted teeth. The lateral cephalogram represents a true lateral view of the skull, and, for the present purposes, of the anterior maxilla in particular (Fig. 2.7a). Although there are many superimposed structures on this area, the outline of a canine may be clearly seen. The direction of the long axis of the tooth in the antero-posterior and vertical planes may be defined, together with the mesiodistal positions of both crown and apex.

If a cephalometric radiograph is not available, the same view of the anterior maxilla may be obtained on an occlusally sized film. This film is held vertically against the cheek

and parallel to the sagittal plane of the skull. The X-ray tube is directed horizontally above and parallel to the occlusal plane from the opposite side of the face, and at right-angles to the film. The result is called the tangential view and has the advantage of simplicity. This view is particularly useful in monitoring progress in the resolution of impacted incisors during active treatment.

At the age at which most patients first present with an impacted central incisor (around 8–10 years), the permanent canine teeth are unerupted and are located both well forward and high in the anterior maxilla. Thus, on the lateral cephalometric or tangential view, right and left canines will be impossible to differentiate individually. The roots of the incisors, at the same height as the canines, as well as the superimposed images of the more inferiorly placed crowns of the erupted incisors and deciduous canines, will all be indistinguishable from one another and from supernumerary teeth that may also be present. For this



Figure 2.9

A dilacerated central incisor seen in the lateral cephalometric radiograph.

reason, the lateral view may be of limited value in cases where there is obstructive impaction, with minimal displacement. When gross displacement is present, however, the outline of the altered axial inclination and height of the tooth can usually be delineated, despite the considerable superimposition of other teeth.

Nowhere is this view a greater asset than when a dilacerated tooth is present, since it separates out this malformed tooth, superiorly, from the root apices of the other teeth and from the permanent canines, because of its relative height (Fig. 2.9). Furthermore, its morphology may be seen to best advantage from this aspect, which allows definitive and accurate diagnosis of the condition to be made, together with its precise relations vis-à-vis surrounding structures. The tangential view should be considered an essential requirement in radiographically recording the dilacerated central incisor.

For maxillary canines, the lateral view is extremely useful. It should be remembered that most impacted maxillary canines are diagnosed in the full permanent dentition, when all the other teeth will have erupted. This demarcates the canine at a higher level than the other teeth.

A postero-anterior cephalometric film is used less routinely in orthodontics, but it

offers the clinician the opportunity to view the maxilla in a different plane, the true postero-anterior view (Fig. 2.7b), which is at right-angles to the lateral cephalogram. The overlap of structures of the base of the skull and the maxilla renders detail of individual teeth less clear, but a good postero-anterior radiograph will show the height of both the crown and the root of a markedly displaced tooth, as with the lateral film. This view also shows whether the root apex of an ectopic posterior tooth is in the line of the arch and how far the crown is deflected in the palatal direction. The bucco-lingual tilt of the long axis of the tooth will be plainly visible (Fig. 2.10). However, the view is less practical in the mandible, where the body is oblique to the central ray. There is usually excessive overlap, more radio-opaque bone and difficulty in discerning even markedly buccolingually displaced teeth.

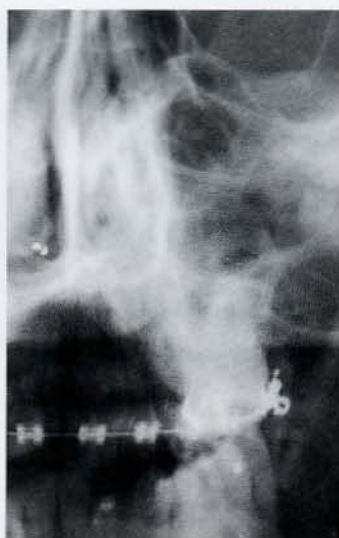
An occlusal projection of the anterior maxilla (Fig. 2.3) offers the possibility to view in the third plane of space, at right-angles to each of the two earlier radiographs, and to record the position of the displaced incisor or canine without overlap. However, for it to be of greatest value, it is important to project the X-ray beam through the long axis of the maxillary teeth, as just described.

Any two of these three views (the lateral cephalogram or tangential view, the postero-anterior cephalogram and the true occlusal) will provide complete information regarding every aspect of the height, bucco-lingual and mesio-distal location of the crown, the root, and the degree of tilt of the long axis of the impacted tooth and its relation with neighbouring teeth. The postero-anterior and occlusal views, however, are not always as clear as is desirable, and they may need to be repeated or discarded. The lateral cephalometric or tangential views in a case of bilateral canine impaction may create confusion, since one canine will be superimposed on the other and distinguishing them may be a problem, although other views will usually facilitate differentiation. Two identically oriented and superimposed canines (Fig. 2.7) will obviously not need to be differentiated.

From these aspects, it is very easy to build



(a)



(b)



(c)

Figure 2.10

(a,b) Extracted portion of the lateral and postero-anterior cephalometric views, to show an impacted maxillary left second premolar to be located with its apex in the line of the arch, but superiorly displaced. The crown is displaced palatally, close to the midline and the long axis is strongly palatal, slightly downward and slightly distal. (c) The periapical film gives the misleading appearance of the crown being displaced superiorly and anteriorly. (Courtesy of Dr I Gillis.)

up a three-dimensional picture of the exact position and angulation of the impacted tooth and to define the type of movement that will be necessary to bring the tooth into alignment. When building this composite mental reconstruction of the position of the unerupted tooth in space, the design of the appliance needed to resolve the impaction is simplified and fewer surprises are likely to be encountered. It is, however, an important prerequisite in all these cases to examine a periapical view of the tooth, to eliminate the possibility of local pathology, which could be missed on the extra-oral views.

CT SCANNING

Recently, the use of computed tomography (CT) scanning has been suggested (Ericson and Kurol, 1988a,b) for identifying the exact position of the palatally impacted canine, particularly when root resorption of the lateral incisor is suspected (Ericson and Kurol, 1987). CT scanning is a method in which clear serial radiographs may be taken at graduated depths in any part of the human body (Fig. 2.11a). At the same time, this technique allows the elimination of the superimposition of other structures that we have seen will

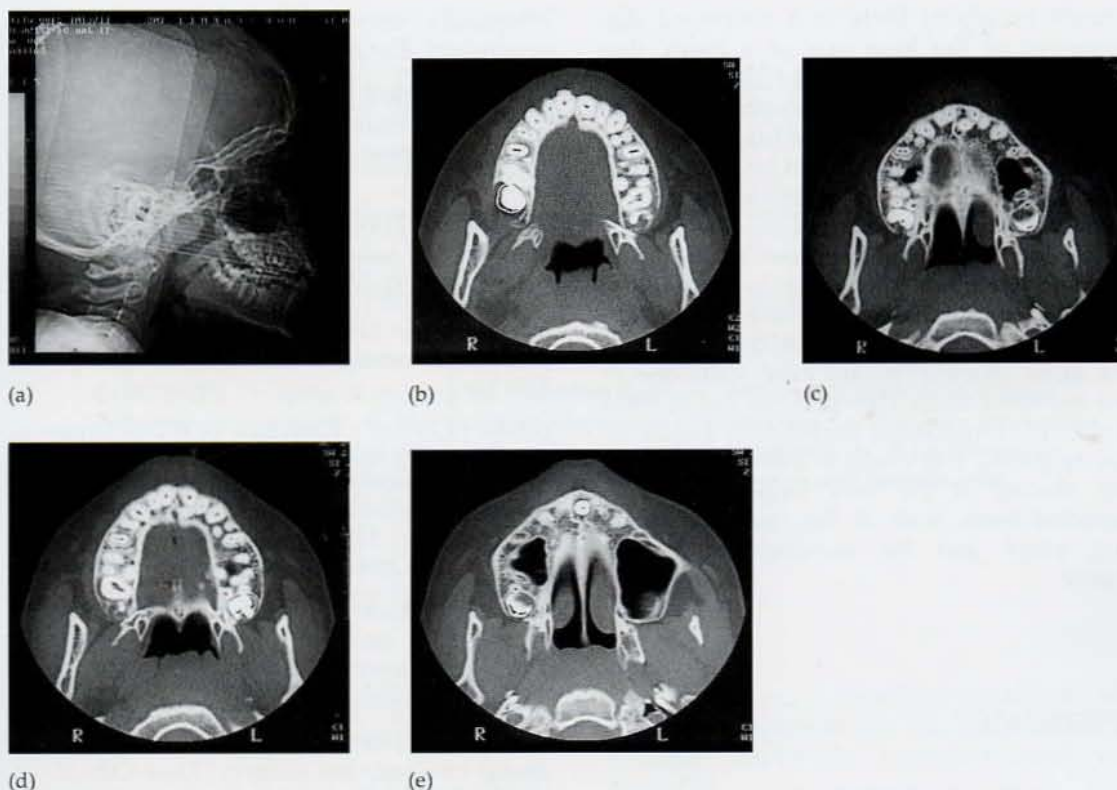


Figure 2.11

(a) The lateral skull radiograph shows the direction and separation of the individual CT 'slices'. (b-e) These sections depict most clearly the midline supernumerary tooth and its relationship to the adjacent teeth in all three planes of space. (Courtesy of Dr D Eisenbud.)

obscure the image of the object that we are attempting to view in traditional radiography. In reconstructive dentistry, this method has been developed to allow accurate placement of implants (Schwarz et al, 1989). Although it has excellent potential for the diagnosis of the position of impacted and supernumerary teeth, the large dosage of radiation is difficult to justify for all except the exceptional case.

By viewing serial radiographic 'slices' of the maxilla (Figs 2.11b-e), the relationship of the impacted tooth to adjacent teeth, in all three planes of space, may be accurately assessed, as can the positions of crown and apex and the inclination of the long axis of the

tooth. In the following chapters, we shall describe how the relative difficulty of bringing these teeth into their proper position is dependent on advance knowledge of the exact positions of both crown and root apex. We shall conclude that variations in root apex displacement, in particular, prejudice both the ability of the orthodontist to complete the exercise and the periodontal prognosis of the tooth, when the treatment is finally completed. The method may also give accurate information regarding early root resorption, particularly of the buccal and palatal surfaces of the root. This may not be possible to diagnose by any other method, prior to treatment. It therefore makes sense that for those

patients in whom there is a suspected displacement of the long axis of a tooth, due to an abnormal orientation of the root apex or the presence of root resorption (Ericson and Kurol, 1988b), the use of high-resolution computed tomography should be considered.

Although CT scanning units are relatively few and imaging is expensive, their use is increasing, and they are now more freely available to the orthodontist in practice. It may still be difficult to justify using the method on a routine basis for the occasional and more straightforward case with one or two impacted teeth. However, its use in cases of multiple impactions, particularly cleidocranial dysplasia, has much to offer in the accurate placing of the very large number of impacted teeth, both at the treatment planning stage and the subsequent surgical phases.

REFERENCES

- Ericson S, Kurol J (1987) Radiographic examination of ectopically erupting maxillary canines. *Am J Orthod Dentofac Orthop* **91**: 483-92.
- Ericson S, Kurol J (1988a) CT diagnosis of ectopically erupting maxillary canines - a case report. *Eur J Orthod* **10**: 115-20.
- Ericson S, Kurol J (1988b) Resorption of maxillary lateral incisors caused by ectopic eruption of canines. *Am J Orthod Dentofac Orthop* **94**: 503-13.
- Hunter SB (1981) The radiographic assessment of the unerupted maxillary canine. *Br Dent J* **150**: 151-5.
- Jacobs SG (1986) Localisation of the unerupted maxillary canine. *Austr Orthod J* **9**: 313-16.
- Jacobs SG (1987) Exercises in the localisation of unerupted teeth. *Austr Orthod J* **10**: 33-5, 58-60.
- Mason RA (1982) *A Guide to Dental Radiography*, 2nd edn. Wright PSG, Bristol.
- Ong A (1994) An alternative technique to the vertex/true occlusal view. *Am J Orthod Dentofac Orthop* **106**: 621-6.
- Schwarz MS, Rothman SLG, Chafetz N, Rhodes M (1989) Computed tomography in dental implantation surgery. *Dent Clin N Am* **33**: 555-97.
- Seward GR (1968) Radiology in general dental practice. IX - Unerupted maxillary canines, central incisors and supernumeraries. *Br Dent J* **115**: 85-91.

3 SURGICAL EXPOSURE OF IMPACTED TEETH

In collaboration with Professor Arye Shteyer and Professor Joshua Lustmann

CONTENTS • Aims of surgery for impacted teeth • Surgical intervention without orthodontic treatment • The surgical elimination of pathology • Buccally accessible impacted teeth • Partial and full flap closure on the palatal side • A conservative attitude to the dental follicle • Cooperation between surgeon and orthodontist • The team approach to attachment bonding

AIMS OF SURGERY FOR IMPACTED TEETH

For impacted third molars, treatment alternatives and opportunities for choice are few, and, in the majority of cases, extraction is advised. However, for other impacted teeth, this is not so, and several lines of treatment may present (McDonald and Yap, 1986). Nevertheless, in the past, the decision as to how a particular impacted tooth should be treated was most often decided by the oral surgeon, who also, by and large, decided upon and stage-managed the alternatives. This situation has changed in recent years.

Prior to the 1950s, most orthodontists were unprepared to adapt their skills and ingenuity to the task of resolving the impaction of maxillary canines and incisors. Accordingly, the orthodontists themselves referred patients to the oral surgeon, who would decide if the impacted tooth could be brought into the dental arch. Where the circumstances were potentially favourable, the tooth would be surgically exposed, and, when the surgical field was displayed fully, the surgeon would make his assessment of the prognosis of the

case, decide and act solely in accordance with his own judgement. In this way, many potentially retrievable impacted teeth were extracted.

There are no surgical methods, other than transplantation, by which positive and active alignment of an impacted tooth may be carried out. The best a surgeon may do is to provide the optimal environment for normal and unhindered eruption and then hope and pray that the tooth will oblige. With this in mind, therefore, those teeth that were considered worth trying to recover were widely exposed and packed with gauze soaked in Whitehead's varnish, to protect the wound during the healing phase and to prevent rehealing of the tissues over the tooth. For a variety of reasons, several other steps were taken, depending upon the preferences and beliefs of the operator, with the aim of providing 'that extra something' that would improve the chances of spontaneous eruption still further. These measures were often very empirical in nature, and included one or more of the following:

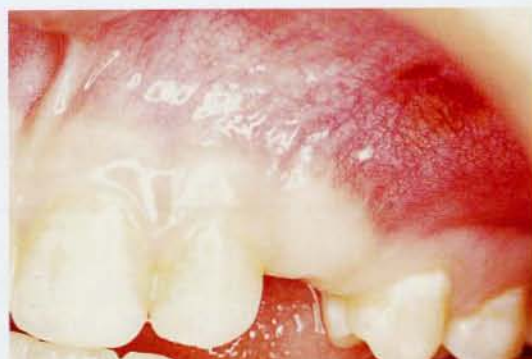
- (a) clearing the follicular sac completely, including in the CEJ area;

- (b) clearing the bone around the tooth, down to the CEJ area, to dissect out and free the entire crown and the coronal portion of the root of the impacted tooth;
- (c) 'loosening up' the tooth, by sublaxating it with an elevator;
- (d) bone-channelling in the desired direction of movement of the tooth;
- (e) packing gauze or hot gutta percha into the area of the CEJ, under pressure, in order to apply force to deflect the eruption path of the tooth in a particular direction.

In those years, few patients were referred to the orthodontist until full eruption had been achieved and the tooth then needed to be moved horizontally into line with its neighbours. Up to that point, the problem was considered to be within the realm of the oral surgeon. In many cases, 'success' in achieving the eruption of the tooth was pyrrhic and often subordinated to failure of a different kind, namely the periodontal condition of the newly erupted tooth and its poorer survival potential – its prognosis. This was the inevitable result of the aggressive and over enthusiastic surgical techniques that had been used, which typically left the tooth with an elongated clinical crown, a lack of attached gingiva and a reduced alveolar crest height (Odenrick and Modeer, 1978; Boyd, 1982, 1984; Becker et al, 1983; Kohavi et al, 1984a, b).

SURGICAL INTERVENTION WITHOUT ORTHODONTIC TREATMENT

We come across cases in which the only clinical problem relates to the impacted tooth, the occlusion and alignment being otherwise acceptable. For these patients, the following question needs to be addressed: What surgical methods are available that may be expected to provide a more or less complete solution, without outside assistance? To be in a position to answer this question, it is necessary to provide a description of the position of the teeth that will respond to this kind of treatment.



(a)



(b)



(c)

Figure 3.1

(a) A 16-year-old female exhibits an unerupted maxillary left canine, which has been present in this position for 2 years and has not progressed. (b) The tooth was exposed, and the flap, which consisted of thickened mucosa, was apically repositioned. (c) At 9 months post-surgery, the tooth has erupted normally. (Courtesy of I. Shapira.)



(a)



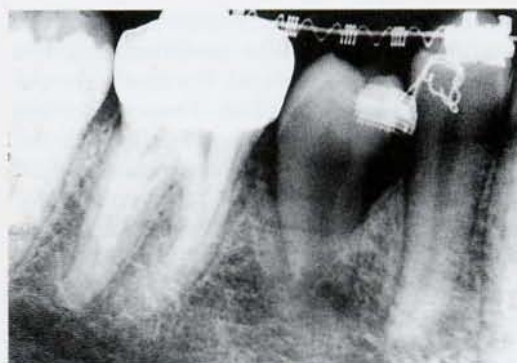
(b)

Figure 3.2

(a) Soft tissue impaction of maxillary central incisors. (b) Apical repositioning of both buccal and palatal flaps to leave the incisal edges exposed. (Courtesy of Professor J Lustmann.)

Exposure only

A superficially placed tooth, palpable beneath the bulging gum, is an obvious candidate. This type of tooth may be seen in the maxillary canine area (Fig. 3.1), but also in the mandibular premolar area (see Fig. 1.8) and the maxillary central incisor area (Fig. 3.2), usually where very early extraction of the deciduous predecessor was performed while the immature permanent tooth bud was still deep in the bone and unready for eruption. Healing occurred, and the permanent teeth are unable to penetrate the thickened mucosa (DiBiase, 1971; Andreasen and Andreasen, 1994). Removing the fibrous mucosal covering or incising and resuturing it to leave the incisal edges exposed (Figs 3.1a and 3.2b) will

**Figure 3.3**

Following exposure and packing, the tooth has erupted spontaneously, but the bone level is compromised.

generally lead to a fairly rapid eruption of the soft tissue impacted tooth, particularly in the maxillary incisor area. The more the tooth bulges the soft tissue, the less likely is a reburial of the tooth in healing soft tissue and the faster is the eruption.

Exposure with pack

Taking this one step further, we can see that a less superficial tooth requires a more radical exposure procedure, and may need a pack to prevent the tissues from rehealing over the tooth. While the surgeon may be rewarded with spontaneous eruption, this will take longer, and a compromised periodontal result should be expected (Fig. 3.3).

We have defined over-retained deciduous teeth as teeth still present in the mouth when their permanent successors have reached a stage of development that is compatible with their full eruption. These deciduous teeth may then be considered as obstructing the normal development that would be expected to proceed in their absence. The deciduous teeth should be extracted, but provision should be made to encourage the permanent teeth to erupt quickly. Many of these permanent teeth with delayed eruption are abnormally low in the alveolus, and are in danger

of being reburied by the healing tissue of the evacuated socket of the deciduous tooth. Accordingly, the crowns of the teeth should be exposed to their widest diameter and a surgical or periodontal pack placed over them and sutured in place for 2-3 weeks. This will encourage epithelialization down the sides of the socket and, generally, prevent the re-formation of bone over the unerupted tooth.

Exposure with pressure pack

Mild mesial impaction of a mandibular second permanent molar beneath the distal bulbosity of the first permanent molar is a condition that often responds to surgical intervention and packing only. This involves exposure of the occlusal surface of the tooth and the deliberate wedging of some form of pack in the area between the two teeth and leaving it there for two or three weeks. During this time, the pressure will often succeed in eliciting a distal movement of the impacted molar, which may then erupt more freely when the pack is removed. The degree of control available to the operator in judging the amount of pressure applied and the extent to which the pack interferes periodontally is minimal, and lasting damage to the periodontium is likely. Success in bringing about an improved position of the tooth may thus not be matched by the health of its supporting structures in the final analysis.

THE SURGICAL ELIMINATION OF PATHOLOGY

Soft tissue lesions

In Chapter 7, we shall refer more specifically to benign tumours. Surgical treatment is the only treatment that is indicated for these conditions in the first instance. This should be performed without delay, if only for reasons of obtaining biopsy material to confirm the innocence of a tentative diagnosis. Orthodontic treatment should be suggested then – but begun only after a filling-in of bone has

brought about an improvement of the positions of the grossly displaced teeth, together with an improvement of the bony defect that will be evident in the anatomy of the alveolar bone in the area, which may take many months to occur. During this time, the psychological preparation of the patient for the proposed orthodontic treatment may be undertaken, which must begin with seeing positive results from a preventive dental health programme aimed at eliminating marginal gingival inflammation and reducing the caries incidence for that patient.

Hard tissue obstruction

Obstructive impaction invites the logical step of removing the offending body causing the non-eruption. On many occasions, this is performed by the surgeon, without recourse to orthodontic assistance, and enjoys a varying degree of success. In Chapter 5, we shall refer to the reliability of spontaneous eruption, following the various surgical procedures involved in the treatment of impacted incisors. For the present discussion, we must recognize that there is a significant number of cases in which eruption does not occur in a reasonable time frame.

Undoubtedly, the position of most unerupted teeth improves with the passage of time, following the removal of the obstruction, be it a supernumerary tooth, an odontome, residual deciduous roots or an infra-occluded primary tooth. However, many of these teeth do not erupt without assistance, because of local disturbances caused by the recently removed obstruction and the healing tissues.

A hard tissue body occupies much space, and may cause a gross displacement of the developing tooth bud of the normal tooth, both in terms of overall distance from its place and in that the orientation of its long axis is also deflected. Thus the root or the crown of the tooth may be deflected mesially, distally, lingually or buccally, compromising its chances of spontaneous eruption. Abnormally shaped roots may develop in the

cramped circumstances in which they find themselves, between the displacing influence of the pathological entity and the adjacent teeth, on the one hand, and the floor of the nose or lower border of the mandible (Becker and Shochat, 1982), on the other.

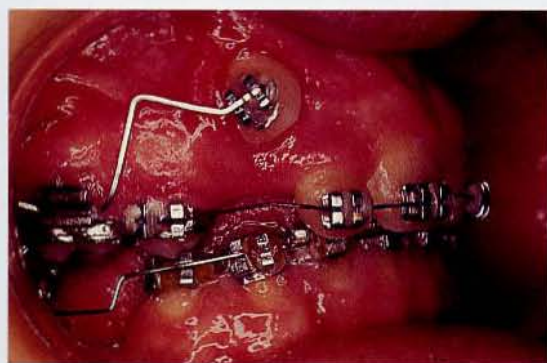
Non-eruption disturbs the eruption pattern of the adjacent teeth, which then assume abnormal relationships to one another, usually characterized by space reduction and tipping. This then provides a secondary physical impediment to the eruption of the impacted tooth.

Infraocclusion

As we shall discuss in Chapter 7, infra-occluded permanent teeth are usually ankylosed to the surrounding bone, and, as such, cannot respond to orthodontic traction. In many cases, the ankylosed area of root is minute, and may be easily broken by a deliberate but gentle luxation of the tooth. This is usually performed with an elevator or extraction forceps, and is done in such a way as to slightly (very slightly) loosen the rigid con-

nection of the bony union, which is unbending. The tooth is not removed from its socket, nor is the aim even to tear the periodontal fibres. The purpose is to return the tooth to the same degree of mobility that is characteristic of a normal tooth.

Unfortunately, the fate of the tooth that has undergone this procedure is usually a rehealing and reattachment of the ankylotic connection, leading to a return to the original situation. Accordingly, this approach can only be successful if a continuously active traction force is applied to the tooth from the time of its luxation. This force may then act to modify the rehealing of bone, due to the distraction osteogenesis (Ilizarov et al, 1980; Altuna et al, 1995) that it causes. If the range of force is small and loses its potency between visits for adjustment, reankylosis will result. Thus, to be effective, it must be of sufficient magnitude to cause distraction and of sufficient range to remain active between one visit for adjustment and the next. The risk is that a poor biomechanical auxiliary, insufficient force levels or missed appointments may cause the exercise to founder, owing to re-establishment of the ankylosis bridge.



(a)



(b)

Figure 3.4

(a) A high buccal canine exposed by circular incision of the sulcus mucosa. (b) Following alignment, the oral mucosa is attached directly to the gingiva. (Courtesy of Dr G Engel.)

BUCCALLY ACCESSIBLE IMPACTED TEETH

There are four methods available to resolve an unerupted tooth that is on the buccal side of the ridge and high in the sulcus. These are as follows.

1 *A circular incision*

This may be made in the sulcus mucosa, immediately over the crown, to expose the bony crypt immediately beneath. In order to do this, the entire surgical procedure would inevitably be sited above the attached gingiva (Fig. 3.4).

From the surgical point of view, suitable access will have been provided to allow the bonding of an attachment. From the orthodontist's standpoint, the application of light extrusive forces of good range presents no particular difficulties, and reduction of the impaction may be very rapid.

Whilst this may satisfy both surgical and orthodontic demands, the periodontic result will be poor, and there will be an elongated clinical crown. The band of attached gingiva will be turned palatal to the aligning tooth, which could create a factor for buccal positional relapse at the end of treatment. On the labial side, the tooth will be invested with the thin oral mucosa, which offers a poor long-term prospect under conditions of normal function for the fully corrected canine.

In many of these cases, eruption may occur naturally, with the tooth emerging through the sulcus mucosa and above the attached gingiva. Prompt treatment will be needed if these teeth are to acquire a normal periodontal environment, which will dictate preempting their eruption. The circular incision method provides no solution to this.

2 *Apically repositioned surgical flap*

This method, a recognized and accepted procedure in periodontics, was first described in the context of surgical and orthodontic treat-

ment of unerupted teeth by Vanarsdall and Corn (1977). In their method and in the absence of the deciduous canine, a mucogingival flap is raised from the crest of the ridge that includes attached gingiva (Fig. 3.1). If a deciduous canine is present, the flap is designed to include the entire area of buccal gingiva that invests it, and the deciduous tooth itself is extracted. In either case, the flap is detached from the underlying hard tissue some way up into the sulcus, to expose the canine. The flap is then sutured to the labial side of the crown of the permanent canine, to cover the denuded periosteum and overlying the cervical portion of the crown, while the remainder of the crown remains exposed. Subsequent eruption of the tooth is accompanied by the healing gingival tissue, and, when the tooth takes up its final position in the arch, it will be found to be invested with a good width of attached gingiva.

When left untreated, palpable unerupted teeth may take many months to break through the mucosa and reach their final positions. When an apically repositioned flap is performed, eruption is speeded up. Additionally, with the sutured soft tissue applying some pressure on the buccal side of the tooth and assuming there to be space in the immediate vicinity, a buccal displacement may be spontaneously reduced.

If the unerupted tooth is very high, the surgical flap, which stretches from below the attached gingiva on the crest of the ridge or at the free gingiva of the deciduous tooth up to the depth of the sulcus, would be excessively large. Under these circumstances, the procedure is not recommended, since the apically repositioned flap would then leave a wide area of the labial bony plate unnecessarily exposed to the oral environment.

In a more recent study, Vermette et al (1995) found several drawbacks in relation to the aesthetic and periodontal results of the apically repositioned flap technique for buccal canines, which had not been previously reported. In unilaterally affected and treated cases, the clinical crown length was greater than the untreated control side and an uneven and unaesthetic gingival margin was often produced (Fig. 3.5). There was also a



Figure 3.5

Uneven and unaesthetic gingival margin, bands of gingival scarring and a long clinical crown, following apical repositioning of the flap covering this formerly buccally impacted canine.

degree of attachment loss and bone loss on the labial surface, which was considered as possibly related to an increased potential for plaque accumulation that the procedure seems to encourage.

Vermette et al (1995) also reported a vertical orthodontic relapse in 61% of the teeth that had been erupted using orthodontic appliances, after treatment had been completed. They speculated that the reason for this is that, following the apical repositioning, the gingival tissue heals to the adjacent mucosa, producing soft tissue bands of gingival scarring. As the tooth is pulled incisally, this mucosa is stretched down with it, towards the alveolar crest. This then leads to a relapse tendency when the forces are released. However, the periodontal attachment was unaffected when compared with the unoperated control side.

Nevertheless, an important advantage of the method is that the buccally impacted canine is exposed to the oral environment, and remains accessible for attachment bonding. In some cases, where orthodontic treatment is not needed for other problems, the progress of the tooth may be followed for many months, until full eruption will have

occurred, without the use of appliances (Fig. 3.1). In others, an attachment may be bonded by the orthodontist at any appropriate later date and active extrusion subsequently undertaken.

3 Full flap closure

This was proposed by McBride (1979), and is a procedure that may be used regardless of the height of the canine. A buccal surgical flap is raised as high as is necessary to expose the unerupted canine. An attachment is then bonded to the tooth, and the flap is fully sutured back to its former place. A twisted stainless steel ligature wire that has been threaded through the attachment is then drawn inferiorly and through the sutured edges of the replaced flap, at the crest of the ridge, or through the socket vacated by the extracted deciduous canine.

Spontaneous eruption is less likely to occur than when the tooth remains exposed, following apical repositioning, and active orthodontic force will probably need to be applied to the tooth to bring about its eruption. In this method, the tooth erupts toward and through the attached gingiva area, which then becomes attached to the tooth and the surrounding alveolar process.

This closed-eruption method compares favourably (Vermette et al, 1995) with the apically repositioned flap method described above. The full flap closure method (closed eruption technique) shows no tendency for an apical and uneven gingival position, nor does it produce a long clinical crown. There is no loss of attachment on the buccal aspects, nor is gingival scarring produced with this method, and the periodontal attachment is completely normal.

A further and particularly significant difference between the two methods of surgical exposure of the buccal canine reported in this work was that in the full closure method, there was no vertical relapse of the treated canine following the completion of treatment. However, the closure of the flap at the end of the surgical stage dictates the necessity for the



Figure 3.6

Buttonholing.

placement of an attachment, while the tooth is visible and in the surgeon's operating room. It cannot be left until a subsequent visit.

The method has unequivocal advantages over the apically repositioned flap method, and these have been attributed to the close similarity of the conditions brought about by full flap closure to those associated with normal tooth eruption (Crescini et al, 1995). On the basis of their results, Vermette and co-workers question the indications for the continued use of the apically repositioned flap method.

A significant problem with the closed eruption technique is sometimes caused by a poor choice of bonded orthodontic attachment. Since the midbuccal position of this tooth is easy to expose and to bond to, the orthodontist may be tempted to use a conventional orthodontic bracket in this instance (Wong-Lee and Wong, 1985). Because of the buccal prominence of the tooth, the lack of buccal bone and the relative tightness of the replaced flap, damage may be caused to this mucogingival tissue by the bulk of wide and high-profile conventional brackets (see Fig. 4.4), which may lead to a breakdown of the overlying tissue, to cause a dehiscence or even 'buttonholing' (Fig. 3.6). Once again, therefore, the use of an eyelet offers significant advantages due to its more modest dimensions and lower profile, at least until the tooth has erupted and been brought into close proximity to the labial archwire.

4 The relief of crowding to reduce canine displacement

If the displacement of the canine has been due to crowding then it follows that spontaneous improvement of the position of the canine may well occur if the crowding is eliminated.

Time may not be on the side of the clinician opting for this approach, since the tooth may erupt through the oral mucosa if delay is incurred. Nevertheless, for the case in which this approach is to be used, a full case analysis is required, leading to a diagnosis and treatment plan for the overall malocclusion. If the crowding is to be dispersed by distal movement of the molars, it will take a longer time before space is available in the canine region, which is the most common area where this type of problem occurs. Considerable delay must be expected while the treatment is proceeding, before spontaneous improvement of the canine position may be seen. On the other hand, a premolar extraction will provide immediate relief of the crowding and an excellent opportunity for a self-correction of the buccal displacement and, with it, the disappearance of the potential periodontal hazard.

PARTIAL AND FULL FLAP CLOSURE ON THE PALATAL SIDE

Occasionally, impacted teeth that are located on the palatal side are palpable immediately beneath the palatal mucosa. The surgical removal of a circular section of the overlying mucosa (see Fig. 6.26) to leave the tooth exposed is tempting and has obvious advantages. However, the palatal mucosal covering is very thick and will leave a broad cut surface, which will tend to close over unless its edges are more radically trimmed back and the dental follicle removed. Thus, for a deeply placed tooth, the exposure will additionally need to be maintained using a surgical pack. This type of surgical approach will therefore leave the tooth with a soft tissue deficiency and a long clinical crown at the completion of the orthodontic alignment.

As we have described for the buccal side, full flap closure on the palatal side requires attachment placement on the exposed tooth, prior to resuturing. This then allows the tooth to be exposed with the minimum of tissue removal and consequent surgical trauma. When this is done and given appropriate orthodontic mechanics, the final result will show that the bone support for the tooth, as well as the health and appearance of the mucogingival tissues, are at their best. The accumulated evidence that has been presented in the various clinical comparisons of surgical methods of exposure (Heaney and Atherton, 1976; Wisth et al, 1976; Odenrick and Modeer, 1978; Boyd, 1982, 1984; Becker et al, 1983; Kohavi et al, 1984a,b; Crescini et al, 1995; Vermette et al, 1995) provide a scientific basis to recommend the full flap closure approach over any other.

A CONSERVATIVE ATTITUDE TO THE DENTAL FOLLICLE

The dental sac or follicle develops from a mesodermal condensation of cells on the outer surface of the external enamel epithelium of the enamel organ of a forming tooth, into a fibrovascular capsule. The follicle has an inner vascular plexus through which the enamel organ is supplied with nutrients during growth, and an outer vascular plexus concerned with enlarging the bony crypt in which the tooth germ lies. The follicle encompasses the entire tooth germ, and, as the root portion of the tooth is formed, the adjacent part of the follicle transforms to become the periodontal membrane, connecting the cementum covering of the developing root to the developing alveolar bone.

The enamel cuticle is made up of a keratinous deposit from the ameloblasts and the reduced enamel epithelium, and is continuous with Hertwig's epithelial root sheath. This separates the crown of the tooth from the follicle, from which the root develops and cementum forms. Because of this separation between follicle and enamel, cementum is not formed on the crown of the tooth.

Eruptive movements bring the tooth follicle into close contact with the oral mucosa, their epithelia fuse, and the tooth thus breaks through an epithelium-lined opening. As eruption proceeds, the remainder of the follicle everts and becomes turned 'inside out', with the reduced enamel epithelium forming the gingival cuff and the most superficial point of attachment.

When impacted wisdom teeth are removed surgically, the dental follicle is always carefully dissected out to prevent the possible later occurrence of cysts that may arise from residual follicle epithelium. However, when a tooth is exposed, only its surrounding follicle has an important function to fulfil. This difference in attitude to the follicle of a tooth committed for extraction, compared with that of a tooth that is to be exposed and subsequently erupted into the mouth, is basic and important to understand.

From studies of the causation of external crown resorption of long-standing buried teeth, it has been found that pathological changes occur in the follicle surrounding its crown (see Fig. 6.11) – changes that have brought the enamel surface into direct contact with the surrounding tissues (Blackwood, 1958). It is easy to draw a parallel between this condition and the artificially produced environment of an impacted tooth that has been surgically exposed and has subsequently become reburied in the tissues. If, for whatever reason, the tooth does not erupt spontaneously, there will be long-term direct contact between the tissues and the enamel of the tooth.

In clearing the surrounding tissues for the purpose of creating an adequate opening, which will not eventually close down, the surgeon will, generally, deliberately and completely remove the follicle surrounding the tooth (Fig. 3.7). Should spontaneous eruption then occur, the oral epithelium will grow down the sides of the opening. It will then attach more apically on the tooth than normal, and a compromised gingival attachment will result. The erupted tooth will have a longer clinical crown and reduced alveolar crest height.

The application of orthodontic traction only



(a)



(b)

Figure 3.7

(a) A left impacted maxillary central incisor has been exposed and the entire follicular sac removed, prior to cementing a band (case treated before the advent of direct bracket bonding to etched enamel). (b) Two years post-treatment shows poor gingival content and positional deterioration.

requires an opening in the follicle that is large enough for the attachment to be placed, while the rest of the follicle may be left intact. The surgical flap may then be fully sutured back and the wound completely closed. Orthodontic traction brings the tooth towards the oral cavity, and the follicle fuses with the oral mucosa, to mimic normal eruption. This leads to the establishment of a normal gingival attachment (Crescini et al, 1995).

A new look must be taken at the surgical plan for the exposure of unerupted teeth. If bonding will not take place at surgery then a wider exposure must be performed and a surgical pack may need to be placed, in order to prevent the reclosing of the wound. It is

important to avoid the over-zealous surgical removal of the follicle and damage to the cemento-enamel junction area by forceful placement of the pack, a poorer result should be expected. Attachment bonding must subsequently be performed at a convenient time after pack removal, at the orthodontist's leisure. However, at this time, the healing and swollen gingival tissue surrounding the exposed tooth will be tender, will bleed with minimal provocation and will be covered with plaque, since effective toothbrushing is unlikely to have been possible.

A wide flap design has the advantage of displaying the area of bone covering the tooth, which is helpful in identifying of the exact site of the tooth. A canine tooth buried in a bony crypt in the palate will alter the shape of the palate inferiorly by creating a distinct bulge of thinned bone, and this will be all the more obvious if much of the surrounding bone is also visible. This is just as true in the labial plate of the maxilla and in the buccal or lingual plate of the mandible, where the tooth in question may be a maxillary central incisor, a second premolar or any other tooth. A generous flap design helps to distance the edges and underside of the flap from the field of operation is important if contamination with blood is to be avoided during bonding.

We may summarize the advantages and disadvantages of complete flap closure with the alternative technique in which exposure is maintained by reducing the size of the flap and packing the wound.

Primary full flap closure

Advantages:

- rapid healing
- less discomfort
- good post-operative haemostasis
- less impediment to function
- conservative bone removal
- immediate traction possible
- reliability of bonding.

Disadvantages:

- presence of orthodontist required
- bond failure dictates re-exposure
- difficulty in gaining dry field.

Secondary closure with pack

Advantages:

- orthodontist's presence unnecessary
- bond failure – needs no surgery.

Disadvantages:

- more discomfort
- wider bone exposure
- many visits to change packs
- greater risk of infection
- bad taste and smell in mouth
- bonding reliability poorer
- delayed initiation of traction
- poorer periodontal condition.

Once the bony surface has been bared and the location of the buried tooth identified, the thin overlying bone may be lifted off very easily. The surgeon will generally use a sharp chisel with light hand pressure to cut open the bony crypt and to remove the superficial part of its wall. The bone is often paper thin, and can even be cut with a sharp scalpel. Immediately beneath the bone, the dental follicle will be seen to glisten in the beam of the operating lamp. A window should be cut in the follicle to fully match the extent of the very minimal bony opening that has already been achieved, in order to see the orientation of the tooth as it lies in its crypt.

As we shall describe in later chapters in this book, it is important to place the attachment as close as possible to the midbuccal position of the crown of the tooth, in order that traction will tend to improve any existing rotation, thereby reducing the amount of mechanotherapy to which the tooth will need to be subjected. For this reason, where a rotated tooth is exposed, the bony opening should be extended around the crown of the tooth, towards the midbuccal area of the crown, provided that this may be done with ease and with the infliction of relatively little further surgical damage. In this instance, flap replacement may be completed and the pig-tail ligature, tied into the newly placed attachment, drawn in the direction of the proposed target site in the dental arch.

During exposure of the crown of a tooth, instrumentation of the enamel surface is not detrimental to the eruption process or to

the quality of the treated result. However, exposure and instrumentation of the root surface are potentially damaging. Exposing the root surface pre-supposes that the cemento-enamel junction, the natural attachment of the tooth, will have been ruptured, and renewed attachment will probably only be established more apically. Additionally, periodontal fibres are severed, cementum exposed, and subjected to drying (suction and air syringe) and contact with foreign substances (etchant and bonding materials). This can lead to the later initiation of a resorption process on the root surface, and to ankylosis and failure of eruption in extreme instances. More common sequelae include seriously reduced bone support, long clinical crowns, poor gingival attachment and contour, chronic gingival margin inflammation and pocketing. In short, the quality of the periodontal result will be compromised.

COOPERATION BETWEEN SURGEON AND ORTHODONTIST

From this discussion, the reader should have come to realize the narrow limitations of the surgeon's ability to materially assist these cases and have come to appreciate that the inclusion of orthodontic procedures offers most cases a better chance of success. Today, orthodontists have come to play a more dominant role in the initial stages of the treatment of impacted teeth, by providing the traction that is necessary to encourage this eruption and, in many cases, to do so successfully in teeth that were previously felt to have a poor prognosis for eruption.

The status of an impacted tooth today is largely dependent on the ability and the ingenuity of the orthodontist to apply light traction in an appropriate direction and with efficient means, once the tooth has been made accessible by the oral surgeon. If orthodontic traction is available to the patient, there is little merit in the surgeon offering any of the other procedures listed above, since there is no available evidence to suggest that these procedures may enhance the opportunity for

orthodontic resolution without causing concurrent harm.

We may therefore conclude that, with respect to the treatment of impacted teeth, the aims of the oral surgeon should be limited to:

- (a) the provision of access to the buried tooth;
- (b) the clearing of any obstruction in the tooth's eruptive path, such as supernumerary teeth, odontomas or thickened overlying mucosa;
- (c) taking an active part with the orthodontist in bonding an attachment to the exposed teeth at surgery, by maintaining haemostasis, which is so critical in ensuring success.

The single most important aim of the surgical episode is to provide the means by which force may be applied to the tooth in question, through several subsequent visits, over a longish time span and in as simple a manner as possible. For this to happen, an attachment has to be securely bonded and a firm ligature drawn to the exterior, to which steel or elastic ligatures or an auxiliary spring may be tied. A sharing of the responsibility for the resolution of the impaction should be undertaken by oral surgeon and orthodontist, with one specialist complementing the other in applying their very special skills to the resolution of the immediate task. Together, they possess all the tools that are needed to complete the job. Their combined efforts should be geared to achieving this.

Bonding an attachment to the tooth at a later visit, a few weeks after surgery has been performed, has the advantage of not requiring the presence of the orthodontist at the surgeon's chairside. However, as will be explained in greater detail in later chapters, by doing this, the surgeon must expose the tooth much more widely, place surgical packs and aim for healing 'by secondary intention' only. Additionally, the reliability of the bonding at this later date is much poorer than when performed at the time of surgery (Becker et al, 1996).

For the purpose of bonding orthodontic brackets to erupted teeth in day-to-day practice, the teeth are first cleaned using a rubber

cup and pumice. The aim of this procedure is to remove extraneous materials, which include soft plaque, dried saliva, organic and chemical staining and deposits that adhere or adsorb to the enamel prisms and that may prevent penetration of the acid. Once these are removed, the enamel surface becomes vulnerable to the orthophosphoric acid etchant, which is the key to successful adhesion of the attachment.

By contrast, newly exposed impacted teeth are completely free of these extraneous materials. Their only covering is Nasmyth's membrane, which is made up of the enamel cuticle and the reduced enamel epithelium, and is about 1 μ m thick. This appears to present no barrier whatsoever to the etching effect achieved by the application of orthophosphoric acid (Becker et al, 1996). Accordingly, there is no advantage to be gained by pumicing these teeth as part of the bonding procedure. Rather, the reverse is the case. To permit the introduction of a handpiece and rubber cup or a small electric toothbrush or hand brush, exposure has to be considerably broader for prophylaxis to be effective. It is difficult to control these implements during the brushing exercise, and, as a direct consequence, the brush or cup traumatizes the exposed bone and soft tissues. This generates renewed bleeding, while giving rise to a dispersal of the pumice over the immediate surgical field.

THE TEAM APPROACH TO ATTACHMENT BONDING

This episode primarily represents an adjunctive surgical procedure, whose aim is to provide a site for the application of an orthodontic force-delivery system. As such, it should be carried out on the surgeon's territory and not in the orthodontic clinic. The orthodontic treatment will have been initiated and orthodontic appliances will, most often, be in place before the surgical exposure is attempted. Orthodontic procedures that need to be carried out during the surgical episode are few and relatively simple, and can all be

performed in the oral surgeon's operatory. However, the orthodontist needs to prepare a small tray of instruments and materials that are not normally available in the operating room, together with a prepared auxiliary spring, which may have been fabricated at a previous visit for the purpose of applying a directional force to the impacted tooth, such as a 'ballista' (Jacoby, 1979), a flexible palatal arch (Becker and Zilberman, 1975, 1978) or a labial spring auxiliary (Kornhauser et al, 1995) (see Chapter 6). The instrument tray should contain the following items:

Instruments

- a fine plier (e.g. a Begg wire-bending plier)
- a fine wire cutter
- a reverse-action bracket-holding tweezer that is closed when not held and releases when its handles are lightly squeezed
- a ligature director
- a mosquito or Matthieu forceps
- a fine scaler

Materials

- etching gel
- composite bonding material, preferably in the form of a no-mix paste and catalyst, which is probably the most manageable type of bonding method that may be used in these special circumstances
- applicators (wood sticks, fine brushes etc.)

Attachments

- eyelets welded to band material, backed with stainless steel mesh; these should be cut and trimmed into patches of various sizes, but not larger than the base of a small bracket
- cut lengths of dead soft stainless steel ligature wire of gauge 0.011".
- elastic thread, elastic ligatures of various sizes or elastic chain

The surgeon reflects a mucoperiosteal flap over the impacted tooth and removes the intervening bone, which is usually very thin and easy to peel with a scalpel blade. The dental follicle is removed from the target area

immediately overlying the crown, and the resultant exposure is not widened more than is necessary to satisfy two basic requirements (Figs 3.8a,b):

- (a) to provide enough enamel surface to accept a small attachment;
- (b) to do so in an area wide enough for adequate haemostasis to allow the bonding procedure to take place without fear of contamination.

The surgeon then moves to the other side of the operating couch, in order to take over the entire responsibility for maintaining the enamel surface free of blood and saliva throughout the critical bonding phase – which is, after all, the point of the entire exercise!

Under the conditions of exposed and oozing soft tissue and bone surfaces, the surgeon will generally need to use a regular suction tip and a second very fine tip in the form of a canula No. 14 or 16, in order to maintain a bloodless field of operation for the bonding procedure. Occasionally, a persistent bleeding point from the bone surface may require either pressure from a blunt instrument or the application of bone wax to occlude the tiny vessel. Soft tissue bleeding may be controlled with an electrocautery, a hot burnisher or, occasionally, ligation of the vessel. Bleeding in the follicular space is best arrested with the use of light pressure from a strip of gauze, which may be left in place until suturing is begun.

The orthodontist proceeds directly to rinsing the tooth surface with sterile saline from a large syringe, through a wide-bore needle, to disperse any blood from the tooth surface, and the saline is evacuated through the broad suction tip, operated by the surgeon. The fine suction tip is then substituted and is made to hover over the entire exposed crown, close to the tooth surface, with the aim of drawing air over the clean enamel. This achieves effective drying.

Liquid etchants should not be used in the exposed surgical field (Kokich and Mathews, 1983), since it is difficult to prevent their spread to the exposed soft tissues and bone surfaces and, perhaps more importantly, to



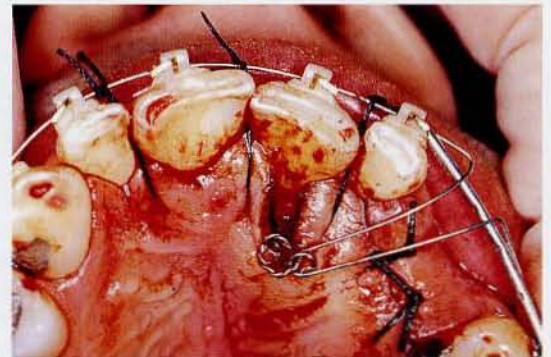
(a)



(b)



(c)



(d)

Figure 3.8

(a) The crown of an impacted canine is exposed, using a wide flap, but with removal of minimal bone. The unexposed crown tip lies between the roots of the central incisors, having traversed the midline suture. (b) An attachment is bonded, while haemostasis is maintained by the surgeon. (c) The flap has been divided to accommodate the ligature pigtail in its desired position, before being fully replaced and sutured. (d) The labial spring auxiliary loop, seen in its passive position in (c), has been turned inwards towards the palate and secured to the stainless steel ligature pigtail.

the area of the cemento-enamel junction and the tooth attachment area. Etchant is best applied as a gel on the end of a fine wooden tooth pick applicator (non-medicated), left in place for 30 seconds and then drawn off by the surgeon, through the fine suction tip, before the surface is rinsed again with saline to remove the last traces of the acid.

Continuation of the use of the fine tip will draw air over the surface of the crown of the tooth until dessication is achieved, and the typical white matt appearance of the etched

surface will then quickly appear. The surface is now ready for bonding.

Many practitioners may be concerned about the adequacy of the dessication, and may also prefer to be sure that no salt crystals remain from the dried saline. Experience shows such worries to be groundless. Nevertheless, to allay them, a final rinse with atomized water from the triple syringe may be followed by a fine compressed air stream to achieve the appropriate degree of dryness of the enamel surface. For this to be success-

ful, the compressed air stream must be very gentle, to avoid splashing up blood from the surgical area, which will contaminate the enamel and cause bond failure.

The prepared eyelet attachment has a pliable base. An attachment of appropriate size should be selected and adapted between the plier and the gloved hand of the orthodontist, to fit the target bonding site. A cut length of 0.011". (0.275 mm) dead soft stainless steel ligature wire is threaded through the eyelet, and, with the use of the mosquito or Matthieu forceps, is twisted into a medium tight and firm pigtail, which should swing freely in the eyelet.

Strictly, any type of bonding agent may be used, including light activated and chemically activated systems. Our own preference is for a chemically activated 'no-mix' system, such as Rely-a-Bond™ (Reliance Orthodontic Products, Inc, Itasca, IL) or Right-On™ (TP Laboratories, Inc, LaPorte, IN). In this system, the attachment is seized in the reverse-action bonding tweezer, and its mesh base is painted with the catalyst liquid. A small quantity of bonding paste is placed on the attachment, which is delivered to the operating area. The etched enamel is checked for dryness once again, and then painted with the liquid catalyst. The attachment is pressed firmly into place on the crown of the tooth, until paste oozes from underneath the mesh base. Even without waiting for initial setting, the viscosity of the paste will hold the attachment in place without the need for any support, and careful fine-tip suction in the surrounding area is probably all that is needed to guarantee bonding success.

Many operators prefer to use the mosquito or Matthieu forceps to carry the attachment to its place and to hold it there until setting has occurred. Unfortunately, the freeing of the attachment from the forceps is achieved by changing the hand grip and unlocking the ratchet that holds the handles closed. These manoeuvres produce considerable jolting and jarring of the attachment, which may seriously undermine the strength of the freshly crystallized bond.

Accordingly, it is better to use the reverse-action bonding tweezer, which may be much

more gently disengaged immediately the attachment is in place and, preferably, before the initial set has occurred. If continuous pressure is desired during the setting period, the ligature director may be substituted for the tweezer and placed with its notch engaged astride the eyelet loop and pressing against it. To free the ligature director, once setting is complete, it is merely withdrawn in the direction of its long axis, without generating any undue lateral jarring. A short time lapse of a few minutes should be allowed before the newly bonded attachment is tested for strength, and this should be done before the flap is resutured.

The replacement of the flap will hide the impacted tooth from sight once again, and it will become evident in later stages that it is prudent to photograph the tooth and its attachment before closure is performed (Fig. 3.8). By photographically recording its position, subsequent decisions related to direction of orthodontic traction may be more reliably made.

As part of the original orthodontic treatment plan, an accurate radiographic assessment of the position of the impacted tooth will have been made and an approach to its orthodontic resolution formulated. With the impacted tooth now in full view, the orthodontist must confirm how it is to be moved to its place. If this is to be performed in a direct line to the prepared place in the dental arch then the pigtail ligature will be swivelled on the eyelet until it points in that direction. The surgeon will then suture the flap back over the wire, leaving its end freely protruding through the cut and sutured edges.

As we shall discuss with regard to a palatally impacted maxillary canine (Chapter 6), sometimes the direction of the traction cannot be pointed straight to the labial archwire, because of the proximity of the roots of adjacent teeth. In this case, the wire may initially need to be drawn vertically downwards, towards the tongue. To achieve this, the pigtail cannot be drawn through the sutured edges of the flap, but rather must be taken through the middle of the palatal area. This means that the reflected flap must be divided into two halves, one on either side of

the pigtail, to accommodate this (Fig. 3.8c). A better alternative is to pass the pigtail through a small pinhole in the palatal mucosa, prior to reapproximation and suturing of the flap. When suturing is completed and the palatal area completely closed off, the orthodontist should shorten the pigtail and turn it up into a hook or circle, to be attached to an active palatal arch, ballista or labial spring auxiliary (Fig. 3.8d).

The application of traction should be immediate, regardless of which method is used. It will be appreciated that later manipulation of the ligature pigtail as it passes through the soft tissues is very unpleasant and even painful for the patient. While subsequent manipulation may only be necessary for two or three additional adjustment visits before the tooth is erupted and the pigtail free of the soft tissue, there is much to be said for the first of these being fully exploited with the application of appropriate traction while a local anaesthetic is operational.

The reliability of the bonding procedure under the circumstances described here has been shown to be extremely high (Becker et al., 1996). In the past, however, bonding in the presence of an open and bleeding wound, involving both soft and hard tissues, was considered strongly contraindicated, since it was thought to be inconsistent with the attainment of a dry and uncontaminated field. This attitude, on the part of the orthodontist, was probably nurtured more out of a reticence to be present at the surgical episode than out of any experience of a high incidence of failure in attachment bonding at that time.

It is important to emphasize the need to properly adapt the base of the attachment to the shape of the recipient surface of the crown of the tooth. Thus the use of standard brackets with 'anatomical' bases, as supplied by the manufacturer, were shown by Becker et al (1996) to fare considerably better in the mid-buccal position of the impacted tooth (80.6%) than on any other surface, particularly the palatal surface, where the chances of its survival are 58.3% – a failure rate of almost 1 in 2! Better still, and at a 96.7% level of reliability, a small attachment (such as an eyelet) on a pliable base, properly and individually

adapted to the form of the recipient site, will allow the orthodontist to work with the greatest degree of confidence.

It will be appreciated that the presence of the orthodontist at the surgical intervention has much to commend it. In the first place, the orthodontist is able to see the exact position of the crown, the direction of the long axis and the deduced location of the root apex. The height of the tooth and its relation to adjacent roots may all be noted, and the orthodontist may plan the strategy of its resolution by direct vision. The orthodontist will be in a position to decide exactly where he or she would like to see the attachment placed from the mechanotherapeutic point of view, and will bond it there.

It is not fair to expect the oral surgeon to be aware of how different attachment positions may affect the orthodontic or periodontic prognosis, and neither should it be expected of him or her to be sufficiently experienced with the bonding technique to do this. For most oral surgeons, bonding is not a procedure that they normally carry out. The presence of the orthodontist allows for bonding to be performed efficiently, with the surgeon and nurse maintaining haemostasis and the necessary dry field.

REFERENCES

- Altuna G, Walker DA, Freeman E (1995) Rapid orthopedic lengthening of the mandible in primates by sagittal split osteotomy and distraction osteogenesis: a pilot study. *Int J Adult Orthod Orthognath Surg* 10: 59–64.
- Andreasen JO, Andreasen FM (1994) *Textbook and Color Atlas of Traumatic Injuries to the Teeth*. Munksgaard, Copenhagen.
- Becker A, Shochat S (1982) Submergence of a deciduous tooth, its ramifications on the dentition and treatment of the resulting malocclusion. *Am J Orthod* 81: 240–4.
- Becker A, Zilberman Y (1975) A combined fixed-removable approach to the treatment of

- impacted maxillary canines. *J Clin Orthodont* 9: 162-9.
- Becker A, Zilberman Y (1978) The palatally impacted canine: a new approach to its treatment. *Am J Orthod* 74: 422-9.
- Becker A, Kohavi D, Zilberman Y (1983) Periodontal status following the alignment of palatally impacted canine teeth. *Am J Orthod* 84: 332-6.
- Becker A, Shpack N, Shteyer A (1996) Attachment bonding to impacted teeth at the time of surgical exposure. *Eur J Orthod* 18: 457-64.
- Blackwood HJJ (1958) Resorption of enamel and dentine in the unerupted tooth. *Oral Surg Oral Med Oral Path* 11: 79-85.
- Boyd R (1982) Clinical assessment of injuries in orthodontic movement of impacted teeth. I. Methods of attachment. *Am J Orthod* 82: 478-86.
- Boyd R (1984) Clinical assessment of injuries in orthodontic movement of impacted teeth. II. Surgical recommendations. *Am J Orthod* 86: 407-18.
- Crescini A, Clauser C, Giorgetti R et al (1995) Tunnel traction of intraosseous impacted maxillary canines: a three-year periodontal follow-up. *Am J Orthod Dentofac Orthop* 105: 464-76.
- Di Biase DD (1971) The effects of variations in tooth morphology and position on eruption. *Dent Pract Dent Rec* 22: 95-108.
- Heaney TG, Atherton JD (1976) Periodontal problems associated with the surgical exposure of unerupted teeth. *Br J Orthodont* 3: 79-85.
- Ilizarov G, Devyatov A, Kamerin V (1980) Plastic reconstruction of longitudinal bone defects by means of compression and subsequent distraction. *Acta Chir Plast* 22: 32-46.
- Jacoby H (1979) The ballista spring system for impacted teeth. *Am J Orthod* 75: 143-51.
- Kohavi D, Becker A, Zilberman Y (1984a) Surgical exposure, orthodontic movement and final tooth position as factors in periodontal breakdown of treated palatally impacted canines. *Am J Orthod* 85: 72-7.
- Kohavi D, Zilberman Y, Becker A (1984b) Periodontal status following the alignment of buccally ectopic maxillary canine teeth. *Am J Orthod* 85: 78-82.
- Kokich VG, Mathews DP (1983) Surgical and orthodontic management of impacted teeth. *Dent Clin N Am* 37: 181-204.
- Kornhauser S, Abed Y, Harari D, Becker A (1996) The resolution of palatally-impacted canines using palatal-occlusal force from a buccal auxiliary. *Am J Orthod Dentofac Orthop* 110: 528-34.
- McBride LJ (1979) Traction - a surgical/orthodontic procedure. *Am J Orthod* 76: 287-99.
- McDonald F, Yap WL (1986) The surgical exposure and application of direct traction of unerupted teeth. *Am J Orthod* 89: 331-40.
- Odenrick L, Modeer T (1978) Periodontal status following surgical-orthodontic alignment of impacted teeth. *Acta Odontol Scand* 36: 233-6.
- Vanarsdall RL, Corn H (1977) Soft-tissue management of labially positioned unerupted teeth. *Am J Orthod* 72: 53-64.
- Vermette ME, Kokich VG, Kennedy DB (1995) Uncovering labially impacted teeth: apically positioned flap and closed-eruption technique. *Angle Orthod* 65: 23-32.
- Wisth PJ, Nordervall K, Boe OE (1976) Periodontal status of orthodontically treated impacted maxillary canines. *Angle Orthod* 46: 53-7.
- Wong-Lee TK, Wong FCK (1985) Maintaining an ideal tooth-gingiva relationship when exposing and aligning an impacted tooth. *Br J Orthod* 12: 189-92.

4 TREATMENT STRATEGY

**CONTENTS • Orthodontic treatment duration • The anchor unit • Attachments
• Elastic ties and modules versus auxiliary springs • Magnets**

ORTHODONTIC TREATMENT DURATION

The opening of adequate space in the arch may initiate movement in an unimpeded impacted tooth, which may start moving in the appropriate direction, sometimes quite quickly. By the time the space is of suitable size and the arrangements for surgery have been made, a new periapical radiograph may show much positive change in its position and lead the clinician to believe that spontaneous eruption will render the surgery unnecessary. If the eruption is likely to occur imminently, or at least within a reasonable period of time, then there is merit in waiting for this to occur.

If, on the other hand, eruption will take many months then the orthodontist must weigh the benefits of avoiding surgery against the drawbacks involved in leaving orthodontic appliances in place for all this time or in removing them before all the teeth are in their appropriate places. Orthodontic appliances raise the level of vulnerability of the teeth to caries and of the periodontium to inflammation – the longer they are in place, the greater the risk. Removing the appliances

before time runs the different risk of having to later replace them to correct a malposition of the newly erupted and erstwhile impacted tooth. In order to solve this dilemma, the clinician may elect to advise surgical exposure and orthodontic traction, thereby expediting the eruption of the tooth and completing the treatment in a very much shorter time frame.

When orthodontic treatment has provided space, and surgery is undertaken to remove a physical obstacle, a similar dilemma may occur. In the absence of the obstacle, the impaction is potentially resolvable, unaided by further treatment. However, the surgical intervention involved in removing the obstacle offers the opportunity of access to the unerupted tooth. Subsequent healing of the wound will deny that access, and, in the event that eruption does not take place, a second surgical intervention in the same area will be necessary and much time will have been wasted confirming that spontaneous eruption will not occur. Clearly, then, the time factor must not be ignored. Orthodontic appliances are in place, and perhaps the space in the arch is unsightly. Without question, orthodontically aided eruption will speed up

the resolution enormously, and, this being so, the patient's best interests are to be served by including this option among the factors to be considered at the planning stage.

When the existence of an impaction is only a small part of an overall complex malocclusion, the time factor becomes more critical. It is quite conceivable and reasonable to estimate that a given overall problem, alone, may require a 2-year treatment period. The complete alignment of an awkwardly placed impacted tooth may add a further year or more to this period. To permit the luxury of a 'wait-and-see' period is to add this time to an already extended 3-year period during which appliances are worn. While the orthodontist may well be rewarded by a much improved position of the impacted tooth, the state of health of the teeth and periodontium may deprive the achievement of all meaningful content.

THE ANCHOR UNIT

At this juncture, it is not the intention to go into the details of appliance therapy. This will come later, as the different groups of impacted teeth that are seen in practice are dealt with. However, some general principles are appropriately given here.

For most malocclusions, quality treatment is best provided by the use of one or other of the recognized fixed appliance treatment techniques. If the dental arches are correctly related and adequate space is present then the teeth are initially 'levelled' to a labial archwire of standardized archform and a given coefficient of elasticity. Later, heavier round or rectangular archwires are substituted to perform root movements that will pave the way to achieving an optimal result. Incorrectly related dental arches will benefit from the use of other appliances, such as headgears, functional appliances and intermaxillary elastics, prior to or in addition to the fixed appliances, while space may be provided by the extraction of teeth or by expanding the arches mesio-distally or laterally.

When dealing with a malocclusion that

incorporates an impacted tooth, modifications must be made to this procedure. Unlike other teeth in the mouth, the impacted tooth may be severely displaced from its normal position in all three planes of space, and much anchorage will be expended in bringing it into alignment. Accordingly, it is necessary to develop a rigid anchor base against which to pit the forces required to reduce the impaction.

At the age at which an impacted maxillary canine is treated, the full permanent dentition (with the exception of third molars) is almost invariably present. Accordingly, a fully multi-bracketed appliance should normally be placed and the entire dentition treated, through the stages of levelling and the opening of adequate space in the arch for the impacted tooth. A heavy and more rigid archwire is then placed into the brackets on all the teeth of the fully aligned and complete dental arch. The aim of this is to provide a solid anchorage base (Kokich and Mathews, 1993) that will not allow distortion of the archwire to occur as a result of the forces that will eventually be applied to the impacted tooth after its exposure. The effect on the anchor unit of forces designed to resolve a grossly displaced canine should not be underestimated, particularly if they are applied for an extended period.

By contrast, at the time when an impacted central incisor requires treatment, only first permanent molars and three permanent incisor teeth are present. Accordingly, alternative means of making the appliance system rigid must be employed before light forces may be applied to the impacted tooth, in order not to compromise the remainder of the dentition.

ATTACHMENTS

To be in the position of being able to influence the future development of an impacted tooth, it is necessary to place some form of attachment on the tooth. These attachments have changed over the years, reflecting the advances made in the field of dental materials.

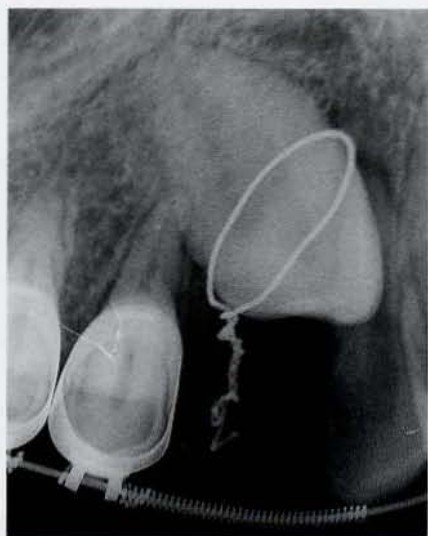


Figure 4.1

Lasso wire encircling the neck of an impacted canine.

Lasso wires

In the years prior to the mid-1960s, a lasso wire (Fig. 4.1) twisted lightly around the neck of the canine had been employed widely, and was used in our earlier cases in the initial stages. It will be readily appreciated that the shape of the crown of a tooth is such that its narrowest diameter is at the CEJ, which is where the lasso wire will inevitably settle.

This will result in irritation of the gingiva and prevent reattachment of the healing tissues in this vital area. It has also been reported that external resorption and ankylosis have been produced in the area of the CEJ following employment of this method (Shapira and Kuftinec, 1981). Given the excellent alternatives that are available today, the lasso wire is obsolete.



Figure 4.2

Threaded pins set into prepared holes, drilled and tapped into the enamel and dentine of the surgically exposed canines.

Threaded pins

Several systems of threaded pins (Fig. 4.2) have been available for many years. Their specific purpose is to provide retention for an amalgam or composite core, to allow the provision of a cast crown in a severely broken down tooth. These threaded pins may also be used to provide the attachment for an impacted tooth. This is a method that was used in the past (Kettle, 1958; Becker and Zilberman, 1978), but has been totally superseded. Its disadvantages include the fact that it is dentally invasive, necessitating a subsequent restoration. Given the difficulties of access to many impacted teeth and the desirability of limiting surgical exposure as much as possible, the orientation of the long

axis of the tooth may be difficult to determine, and the drilled hole may inadvertently enter the pulp – unerupted teeth often have large pulp chambers! Nevertheless, the method is still in use in some quarters (Kokich and Mathews, 1993).

Orthodontic bands

Preformed orthodontic bands largely replaced the lasso wire, and clinical experience with them showed them to be considerably more compatible with ensuring the health of the periodontal tissues. As with the lasso wire, however, the use of a band dictated the very wide surgical clearance of tissue on all sides of the tooth (see Fig. 6.32c), in order to adequately control haemorrhage around the crown and to avoid contamination from oozing blood inside the cement-filled band at the time of placement.

Since the introduction of enamel bonding, all of the above-mentioned earlier methods have become obsolete. The employment of the acid-etch composite bonding technique to the crown of a tooth has much merit (Gensior and Strauss, 1974; Nielsen et al, 1975), notably in terms of the simplicity and reliability of the bond. Its most important advantage is that it requires relatively little exposed surface of enamel for it to be successful – a fact that may contribute greatly to the subsequent periodontal health of the treated result. It is presently without doubt the method of choice from almost every point of view, and it should replace other methods in virtually all circumstances.

Standard orthodontic brackets

As far as the actual choice of type of attachment to be placed on impacted teeth is concerned, there are several salient points to consider regarding the impacted tooth when compared with an erupted tooth that requires to be brought into its position in the dental



Figure 4.3

As the impacted tooth is about to erupt, the high profile Siamese edgewise bracket has fenestrated the swollen gingival tissue.

arch. Edgewise, Begg and other orthodontic brackets represent sophisticated designs of attachment that enable the orthodontist to perform any type of movement on a tooth in the three planes of space. It is not possible, however, to achieve more than tipping, extrusion and some rotation until the bracket reaches and fully engages the main archwire. In other words, its efficacy up to that point is no greater than that of a simple eyelet (Becker et al, 1996).

The base of a conventional bracket is wide, rigid and difficult to convert to the shape of another part of the tooth's surface other than the mid-buccal, for which it has been designed. Thus composite bonding elsewhere on a tooth is very likely to lead to failure (see Fig. 7.6) (Becker et al, 1996).

The standard orthodontic bracket in any technique is relatively large, possesses a wide, high and sharp profile, and, even when placed in alternative positions on the tooth, by force of circumstance at the time of surgery, it is inevitably deeply sited in the surgical wound. The bracket's shear bulk creates irritation as the tooth is later drawn through the soft tissues, particularly the

mucosa (Fig. 4.3). A ligature wire or elastic thread tied to it must also originate deep in the wound, and will be stretched across the replaced flap tissue towards the labial archwire. This increases the possibility of interference with the investing tissues, and leads to inflammation and to probable permanent periodontal damage.

As the displaced tooth moves towards its place in the arch, exuberant gingival tissue bunches up in front of it, which will also lead to impingement by a conventional orthodontic bracket. The existence of the exuberant gingival tissue in advance of the tooth can often cause 'pinching' between it and the teeth in the arch immediately adjacent to it. This is less likely to occur if a deliberately generous space is provided in the arch for the tooth, and this precaution may avoid unnecessary periodontal damage. Because of the close proximity of an impacted tooth to the roots of adjacent teeth, it is often impossible to bond a conventional bracket in its proper place on the tooth. Accordingly, the bracket may have to be sited on the palatal surface of the tooth, where its preformed base is contoured very differently from the shape of the recipient (palatal) area of the tooth, compromising its retentive properties.



Figure 4.4

Eyelets welded to a pliable band material base, backed by steel mesh.

A simple eyelet

An eyelet, welded to band material with a mesh backing (Fig. 4.4), is soft and easy to contour, making its adaptation to the bonding surface more accurate, which makes for superior retentive properties. Its relatively small size and low profile makes the midbuccal position of several of the more awkwardly placed teeth considerably more accessible when compared with the placing of a conventional bracket. Its modest, low-profile, dimensions are also less irritating to the surrounding tissues.

For these reasons, a small eyelet is recommended as the initial attachment, placed at the time of surgery and removed only when the tooth has progressed to the point where it is in close proximity to the archwire. At that time, it should be substituted by the same type of sophisticated bracket that is being used on the other teeth, thereby permitting the initiation of the more intricate root manipulations of the tooth (rotating, uprighting and torquing).

We have seen in Chapter 3 that there are important periodontal advantages to be gained by full closure of the surgical flap at the end of the visit during which the surgical exposure is performed. Thus the impacted tooth is re-covered by the surgical flap, and is lost from sight, unless the impacted tooth is fairly superficially placed. The only manner in which contact may be maintained with it is through the agency of some form of ligature wire, gold chain or elastic thread, which is attached to the eyelet before it is bonded to the tooth.

Since elastic thread can only be tied once, it is not recommended for an attachment that is not clearly visible and accessible in the mouth. Gold chain would appear to be unnecessarily sophisticated, although it is undoubtedly suitable and sufficiently strong for the purpose. The use of a stainless steel ligature is far easier from every point of view, and is readily at hand in the orthodontic and surgical operator. Such a ligature is passed through the eyelet and twisted into a long braid with artery forceps before bonding is undertaken. The braided wire or pigtail

hangs loosely in the eyelet until after bonding and resuturing have been completed, and it should be of sufficient substance for it to be rolled up into a loop that will not easily be unravelled by the application of the extrusive force. On the other hand, it must not be so thick that the effort that is needed to form the loop will seriously test the bond strength of the newly placed attachment. In practice, the use of a dead soft stainless steel ligature wire of 0.011" or 0.012" gauge is generally the most suitable.

It has been recommended that the pigtail be braided in such a way that each two or three turns of the braid are followed by a small loop, then two or three more turns, another loop, and so on. In this way, the braid comprises a convenient chain of loops, which may be shortened as necessary by cutting off the excess, while exploiting the loop closest to the gingival tissue (Ziegler, 1977). However, 'rolling up' the terminal loop of a simply twisted stainless steel ligature as the tooth progresses is simpler and 'user-friendly'.

ELASTIC TIES AND MODULES VERSUS AUXILIARY SPRINGS

At first glance, elastic ties of one sort or another present the orthodontist with the most convenient means of applying light forces to a tooth, with a good range of action. However, their use is usually far more disappointing than one may initially realize.

The manufacturer's spool of elastic thread usually comes in the form of fine hollow tubing, which is easier to tie than a solid thread. Most orthodontists tie the thread with a simple knot that, when tying string, will not unravel. When tying elastomeric thread, however, the knot tends to loosen, and much of the original force of the tie will be lost in this loosening. When under tension, all the materials used to make this elastic thread suffer a high degree of force decay, which is very rapid and very significant. The force levels of chains of various lengths are known to decay to below the force required for tooth movement, in a period of



Figure 4.5

A direct tie using a very short length of elastic thread.

between 1 and 3 weeks, depending upon the amount of tension initially applied (Lu et al, 1993; Storie et al, 1994).

Naturally, a shorter piece of stretched elastic (Fig. 4.5) will have a very short range, and runs the risk of applying an initial excessive amount of pressure if the tie is good – or no effective pressure if the tie loosens. The immature periodontal membrane of the recently exposed tooth and the strength of its bonded attachment could be severely tested. In the case of an unerupted tooth close to the line of the arch, traction applied directly from its attachment to the archwire will generally be very inefficient, requiring frequent changes and producing only a very slow response. For all practical purposes, it is impossible to measure or control such a force.

It is prudent to use more distant sites from which to apply traction to the unerupted tooth, in order to include a greater length of elastic thread to increase the range of the traction force and thereby its effectiveness in moving the tooth over a longer period of time. To do this, the elastic thread needs to be stretched to the target area on the archwire, through the agency of a loop bent into the archwire at that point. The thread may then be tied back to the hook on the molar tube of the same side, with care being taken to insert a stop in the archwire, mesial to the tube, in

order to prevent mesial movement of the molar.

As a general rule, elastic thread should be used as the go-between connecting the non-elastic steel pigtail to a similarly non-elastic and heavy archwire. If a lighter archwire is used then the tie should be made with a steel ligature – the archwire providing the elastic displacement. In this event, however, the distortion of the archwire will bring about an alteration in its shape in both the horizontal and vertical planes, to produce unwanted change in the form of the dental arch and an uneven occlusal plane.

The use of both a flexible archwire and an elastic ligature (Shapira and Kuftinec, 1981) is counterproductive, since the elasticity of the one that exerts the stronger force will be effectively neutralized and will offer no physical advantage over a steel ligature, while the displacement of the weaker element will be the only factor that is active in moving the teeth.

In general, orthodontists use elastic ligature to move teeth by first elongating the material and tying it between two dental elements. Once tied, a natural recoil is exerted along its long axis, pulling the dental elements

towards one another. The amount of elasticity in this direction is limited and, as pointed out above, decays rapidly. However, the lateral displacement of an elongated elastic thread produces a potentially greater range of movement, within suitable orthodontic force levels, than does a longitudinal displacement. This principle may be applied to moving teeth that lie at a distance from the main arch more efficiently and with controlled and measurable forces (Fig. 4.6).

Given a little thought in the planning of their use, elastic ties, chains and modules are extremely helpful in many situations arising because of the presence of impacted teeth. However, properly designed springs, auxiliary to a heavy base arch, are usually more efficient, since their ability to deliver a measured and controlled force is good, the force decay is lower, the variety of metallic alloys available for spring fabrication is broad, and their range of action may be very wide and their direction accurate. These will be illustrated in the discussion of cases as they pertain to the individual groups of teeth in the succeeding chapters.



(a)



(b)

Figure 4.6

(a) The 'slingshot' elastic. A palatally impacted canine has been erupted into the palate (see Chapter 6). The elastic module, placed between the brackets of the lateral incisor and the first premolar, is stretched towards the canine and tied to the buccal eyelet. The steel tube on the archwire maintains the space. (b) The 'slingshot' used on a buccal canine.



Figure 4.7

The 'backpack' magnet. (Courtesy of A Vardimon.)

MAGNETS

Rare earth magnets were developed 40 years ago, but only more recently have they been developed to the point where their reduction in size, with the introduction of lanthanide alloys, has provided the possibility of applying suitable forces that may be exploited in the present context. Vardimon et al (1987) and Sandler et al (1989) have recently presented successful clinical results of the treatment of impacted teeth in humans.

The magnetic attracting force that exists between the two magnets is inversely proportional to the square of the distance between them. This means that a magnet sited on the appliance must be placed close to the magnet that has been bonded to the displaced tooth (Fig. 4.7) and that a grossly displaced tooth may require that the location of the appliance magnet be resited from time to time, in line with the progress of the tooth. The forces generated are centripetally orientated, and it is possible to design their application to move the unerupted tooth in all three planes of space from the very beginning and before the tooth erupts (Vardimon et al, 1991).

The notion that traction may be applied without the need to trail a wire through the soft tissues of the palate, appeals to Vardimon and Sandler and their co-workers. They spec-

ulate that this may improve the final periodontal condition of the teeth, since 'eruption simulates a normal eruption process'. However, given that

- (a) the tooth must nevertheless initially be exposed surgically,
- (b) the magnet must be bonded to it,
- (c) the flap must be replaced and healing must occur, and
- (d) the tooth must then pass through the tissues with this relatively large 'backpack',

this claim may be difficult to justify in practice.

The idea is indeed 'attractive' (Sandler, 1991), but it is not a method that, at present, can unequivocally replace the more traditional and conventional methods described above (Ingervall, 1993; Gianelly, 1993; Rygh, 1993). The use of magnets for impacted teeth is in its early developmental stages, and the methods that have been described appear rather clumsy and inconvenient (Darendeliler and Friedli, 1994). Their greatest disadvantage is the corrosion (Vardimon, 1993) that occurs with their use in tissue and the, so far, unsuccessful attempts at their hermetic isolation. The use of magnets in this context and with the present state of the art offers no advantages over traditional methods, and provides little more than curiosity value.

As these methods become more refined, particularly with the expected future development of even smaller magnets of sufficient power, they may offer some relatively minor advantages over the established methods, which could make them more widely accepted for routine use in clinical practice.

REFERENCES

- Becker A, Zilberman Y (1978) The palatally impacted canine: a new approach to its treatment. *Am J Orthod* 74: 422-9.
- Becker A, Shpack N, Shteyer A (1996) Attachment bonding to impacted teeth at the time of surgical exposure. *Eur J Orthod* 18: 457-64.

- Darendeliev MA, Friedli JM (1994) Treatment of an impacted canine with magnets. *J Clin Orthod* **28**: 639-43.
- Gensior AM, Strauss RE (1974) The direct bonding technique applied to the management of the maxillary impacted canine. *J Am Dent Assoc* **89**: 1332-7.
- Gianelly A (1993) The use of magnets in orthodontic therapy: panel discussion. *Eur J Orthod* **15**: 421-4.
- Ingervall B (1993) The use of magnets in orthodontic therapy: panel discussion. *Eur J Orthod* **15**: 421-4.
- Kettle MA (1958) Treatment of the unerupted maxillary canine. *Dent Pract Dent Rec* **8**: 245-55.
- Kokich VG, Mathews DP (1993) Surgical and orthodontic management of impacted teeth. *Dent Clin N Am* **37**: 181-214.
- Lu TC, Wang WN, Tarng TH, Chen JW (1993) Force decay of elastomeric chains - a serial study. Part 2. *Am J Orthod Dentofac Orthop* **104**: 373-7.
- Nielsen LI, Pryds U, Winkler T (1975) Direct bonding on impacted teeth. *Am J Orthod* **68**: 666-70.
- Rygh P (1993) The use of magnets in orthodontic therapy: panel discussion. *Eur J Orthod* **15**: 421-4.
- Sandler JP (1991) An attractive solution to unerupted teeth. *Am J Orthod Dentofac Orthop* **100**: 489-93.
- Sandler PJ, Meghji S, Murray AM et al (1989) Magnets and orthodontics. *Br J Orthod* **16**: 243-9.
- Shapira Y, Kufninec MM (1981) Treatment of impacted cuspids: the hazard lasso. *Angle Orthod* **51**: 203-7.
- Storie DJ, Regennitter F, von Fraunhofer JA (1994) Characteristics of a fluoride-releasing elastomeric chain. *Angle Orthod* **64**: 199-210.
- Vardimon AD (1993) The use of magnets in orthodontic therapy: panel discussion. *Eur J Orthod* **15**: 421-4.
- Vardimon AD, Graber TM, Voss LR (1987) Hygienic magnetic technique to align impacted teeth. Presented at the 87th Annual Session of the American Association of Orthodontists, Montreal, 1987 (unpublished).
- Vardimon AD, Graber TM, Drescher D, Bourauel C (1991) Rare earth magnets and impaction. *Am J Orthod Dentofac Orthop* **100**: 494-512.
- Ziegler TF (1977) A modified technique for ligating impacted canines. *Am J Orthod Dentofac Orthop* **72**: 665-70.

5 MAXILLARY CENTRAL INCISORS

**CONTENTS • Aetiology • Diagnosis • Treatment timing • Attitudes to treatment
• Treatment of impacted central incisors • Prognosis • Acute traumatic intrusion**

AETIOLOGY

At the age of about 6 years, in most children, a sudden and dramatic changeover occurs in the anterior part of the dentition, with the shedding of the deciduous incisor teeth and the appearance of the permanent incisor teeth. The first permanent teeth to erupt in the young child are usually the mandibular central incisors, although the first permanent molars may sometimes precede them. The mandibular lateral and the maxillary central incisors then erupt at about the same time, at 6.5–7 years.

Under normal circumstances, the maxillary lateral incisors are the last of the incisors to erupt, completing the anterior dentition with their appearance about a year after the eruption of the adjacent central incisors. The spectacle of erupted lateral incisors, associated with the non-appearance of one or both of the central incisors, should always be deemed abnormal, whether or not a deciduous central incisor is still present, and further investigation should be undertaken to ascertain the reason for the aberration.

Congenital absence of a maxillary permanent central incisor, given the presence of per-

manent lateral incisors, is exceptionally rare, although it has been reported. In this situation, the shape of the single central incisor makes it impossible to distinguish whether it belongs to the right or left side. The patient's appearance is abnormal (Figs 5.1a–c) and rather reminiscent of a 'dental cyclops'!

Obstructive causes

Supernumerary teeth

When an existing permanent central incisor does not erupt and the diagnosis of impaction is made, the most common aetiological factor is the presence of one or more midline supernumerary teeth (Howard, 1967; Brin et al, 1982; Zilberman et al, 1992) (see Fig. 1.11). In a study of a sample of schoolchildren (Brook, 1974), the prevalence of supernumerary teeth was found to be between 1.5% and 3.5%. It has also been shown in a different sample group (Tay et al, 1984) that between 28% and 60% of cases with supernumerary teeth will have resultant eruption disturbances of the adjacent teeth. By arbitrarily integrating these two studies, it would seem that between



(a)



(b)



(c)

Figure 5.1

(a) Abnormal lip morphology, absence of philtrum and midline position of single central incisor. (b) Intra-oral view of same patient to show 'square' anatomy of incisor and indeterminate right/left designation. The lateral incisors are laterally flared as part of an otherwise normal 'ugly duckling' stage of development. (c) A view of the palate to show bilateral submucous clefting. (Courtesy of Dr S Geron.)

0.42% and 2.1% of children suffer from impacted central incisor teeth from this cause.

Odontome

Among the other and rarer causes of obstruction that may equally prevent the eruption of a normal central incisor is an odontome. These are very variable in size and type, but, whether they are of the complex or composite type, they usually have a broader and wider cross-section, and their presence will be more likely to prevent eruption of an incisor than will a supernumerary tooth.

Ectopic position of the tooth bud

The development of a tooth bud in an abnormal position or in an abnormal angulation may have no apparent cause, and may thus be attributed to traumatic or genetic factors (Fig. 5.2). As the result of the displacement, normally placed adjacent teeth may provide a physical obstacle to the normal eruption of such a tooth. Alternatively, other physical obstacles, such as the above-mentioned supernumerary teeth or odontomes, may be the reason. While the early removal of an obvious aetiological factor may be strongly



Figure 5.2

An abnormally sited central incisor, whose root apex is close to the canine area. The shape of the root also appears to be abnormal.

indicated, this will not necessarily affect the position of the tooth bud, which will probably continue to develop in its existing location.

Variation in the position of a developing tooth will produce a concomitant variation in its eruption path. When the eruption path is very slightly deflected, the tooth will usually erupt, but with an abnormal angulation of its long axis, mirroring the path that it will have travelled. As its vertical development proceeds, its relationship to the deciduous predecessor is more lateral, medial, lingual or labial. This will bring about a partial and oblique resorption along one side of the root of the deciduous incisor. In due time, the further progress of the permanent incisor brings it into contact with the crown on that side of the deciduous tooth.

The permanent tooth sometimes remains impacted, if insufficient space exists. Alternatively, the tooth may finally erupt adjacent to the over-retained deciduous tooth, possibly into a crossbite relationship, or it may be proclined labially, or a diastema may be produced in the midline. This situation may not be self-correcting, after the belated shedding or extraction of the stubborn deciduous tooth.

Should the position of the developing tooth be more markedly displaced, which is unusual, its potential eruption path will be in a more obtuse direction, and little or no

resorption of the deciduous tooth will occur. In these circumstances, eruptive movements are minimal, and the permanent tooth remains in a more or less unchanged position over a long period. Finally, when positive intervention is undertaken, removal of the cause will need to be supplemented with active appliance therapy for its resolution.

Traumatic causes

Obstruction due to soft tissue repair

The traumatic, sudden and very early loss of the deciduous incisor teeth is most often the result of an accident that delivered a blow to dislodge the tooth, usually while the child was at play. The possibility also exists for this to have been caused by a dental extraction, prompted by the presence of deep caries or following the sequelae of an earlier trauma. This typically happens at 3 or 4 years of age, at a time when the permanent incisors are not ready to erupt and a healing-over of the macerated gingival tissue occurred, without the early eruption of the teeth. In time, changes take place in the connective tissue overlying the tooth germ, which prevents them from penetrating the mucosa (DiBiase, 1971; Andreasen and Andreasen, 1994). By the age of 7 or 8 years, one may see and be able to palpate the bulging profile of the central incisors (See Fig. 3.2a).

Dilaceration

In the early stages of their development, high in the maxilla, the permanent central incisors are situated lingual and superior to the apices of the deciduous incisors. As development proceeds, their position changes, with labial and inferior migration. As this occurs, an oblique resorption of the roots of their deciduous predecessors is initiated.

During this critical period, it frequently happens that the child becomes involved in a traumatic episode, in which a blow is inflicted on the deciduous maxillary incisors, from the front, in a superior and posterior direction. If



Figure 5.3

The tangential view shows severe labial displacement of the root of the deciduous incisor. (Courtesy of Professor J Lustmann.)

these teeth are displaced superiorly (intruded), it follows that a fracture of the alveolar process has occurred and that either the teeth alone, or together with a part of the labial plate of bone, have altered their position.

By and large, this displacement will cause a labial fracture of the buccal plate, and there will be an anterior displacement of the roots of the already superiorly and slightly palatally displaced teeth (Fig. 5.3). This usually has little effect on the unerupted permanent incisors.

Occasionally, however, the thrust of the blow is delivered in the direction of the long axis of the deciduous teeth, and may be transmitted superiorly to the developing permanent tooth. The resorbing root apex momentarily establishes a point of impact with the incisal edge of the crown of the permanent incisor. This will cause the crown of this unerupted permanent incisor tooth to rotate upwards, in its crypt. Since its root is only partially developed at this time, the formed part of the root will rotate with the crown. However, any further root develop-

ment that occurs in the post-trauma period will often continue in the same direction as before, producing a bizarre angle between the pre-trauma and post-trauma portions of the tooth. This will produce the typical dilacerated central incisor, with labial displacement. The site of this junction will depend upon the stage of development of the root at the time of trauma, as will the prognosis of any proposed orthodontic treatment for the tooth.

Palatal, rather than labial, displacement of the crown vis-à-vis the post-traumatic root portion may occur in rare instances, as a variation of the above theme, and is due to a more palatal position of the tip of the developing permanent incisor relative to the apex of the deciduous incisor root at impact. This is a more likely variation in the very young, during the early calcification of the tooth crown when its palatal location is more pronounced.

This scenario for the causation of dilaceration is extremely well known, and probably represents a majority opinion within the profession. However, while this is not ruled out by other authorities, other aetiologic possibilities do exist.

A developmental origin has been suggested as an alternative (Howe, 1971), with the contention that the active process of the development of cysts, odontomes or supernumerary teeth may produce this phenomenon by displacement of the crown of the tooth or by interference and redirection of its root. No history of trauma could be elicited in 70% of another sample (Stewart, 1978) nor could macroscopic or microscopic evidence of trauma, nor the existence of a cyst, odontome or extra tooth. No case was found with both central incisors involved, nor was there damage to neighbouring teeth, which could be expected to occur in at least a few instances if trauma were the cause. These cases also failed to show two distinct and angulated portions to the root, but rather a continuous and tight curve (Fig. 5.4), quite different from those in whom trauma, as an aetiologic factor, was evident.

The conclusion of the latter report was that a fairly high proportion of dilacerations occur as a result of an ectopic siting of the tooth



Figure 5.4

An extracted dilacerated incisor.

germ, whose root development is deformed by its proximity to and the anatomy of the palatal vault in the immediate vicinity.

These explanations are unsatisfactory on several counts. Different cases show an almost identical and very typical anatomy of the tooth, which affects maxillary central incisors exclusively, and virtually never occurs bilaterally. The crown is normally shaped, and the coronal portion of the root shows initial normal development. The apical portion, however, develops along a circular path, in the labio-lingual plane, rather than two straight portions of root at an angle to one another.

Not only is the anatomy typical, but the position and orientation of the tooth is also unique. The crown of the tooth is displaced high on the labial side of the sulcus, without lateral rotation, and its palatal aspect is palpable close to the root of the nose. Often, the root apex is palpable on the palatal side of the alveolus, and may be the sign that influences an unwary surgeon to mistakenly approach exposure of the tooth on the wrong side!

Andreasen and Andreasen (1994) have suggested that the loss of a deciduous incisor may lead to scarring along the eruption path of the permanent incisor, which deflects the developing tooth labially. This runs counter to Stewart's observation that no history of early traumatic loss of the deciduous tooth had occurred in 70% of the cases.

There is an alternative hypothesis. It is possible to read a completely different aetiological interpretation into these constantly occurring

features, and it is pertinent to begin by questioning the reliability of a child's or parent's memory regarding traumatic injury of the front teeth. Severe trauma is rare and always remembered, but non-disfiguring trauma (i.e. trauma that causes neither fracture nor displacement to the anterior teeth) occurs quite frequently in young children, is rarely noted and almost never remembered in the years that follow.

Abrupt and vertically directed force through the long axis of the deciduous tooth will bring about the transference of the impact to the intimately related, unerupted, permanent central incisor. Because the long axis of the permanent incisor has a more labially tipped orientation, the force will be transmitted in an oblique line that runs through the incisal edge and a point on the labial side of the newly forming root, close to or at the root-mineralization interface (Fig. 5.5). Since the blow will be delivered directly to the sensitive cells of Hertwig's root sheath, via the knife edge of the incompleting root at this interface, considerable damage may be inflicted with relatively low force values. It will be appreciated that precision in direction may be more critical than force magnitude.

It is entirely possible that the root sheath may only partially recover from the blow, which may result in an attenuated rate of production of dentine on the labial side of the tooth. With the remainder of the root-forming system continuing to produce dentine unscathed, undeterred and unabated, it follows that the final shape of the root of this tooth will conform to a continuous labially directed curve (Fig. 5.6), until apexification is achieved. Furthermore, since the dental papilla base of Hertwig's root sheath maintains its position within the alveolar process fairly constantly – against the eruptive force of the developing tooth – and provides the platform from which the root is directed, the crown of the incisor moves labially and superiorly for as long as this asymmetrical root mineralization continues. In other words, dilaceration of this classical type, is an anomaly that is traumatic in origin but developmental in its final expression.

This hypothesis provides an explanation

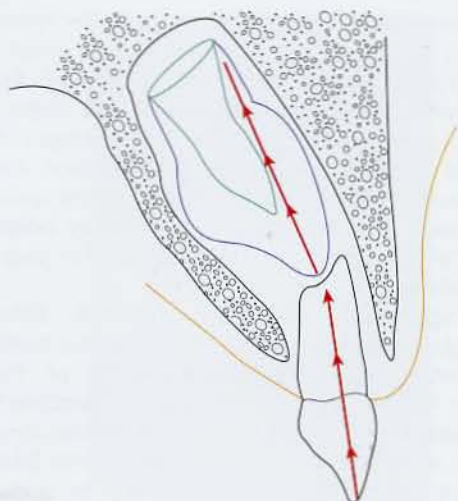


Figure 5.5

A diagram to show how a vertically directed force through the deciduous incisor is transmitted to the labial aspect of the mineralizing root of the unerupted permanent incisor.

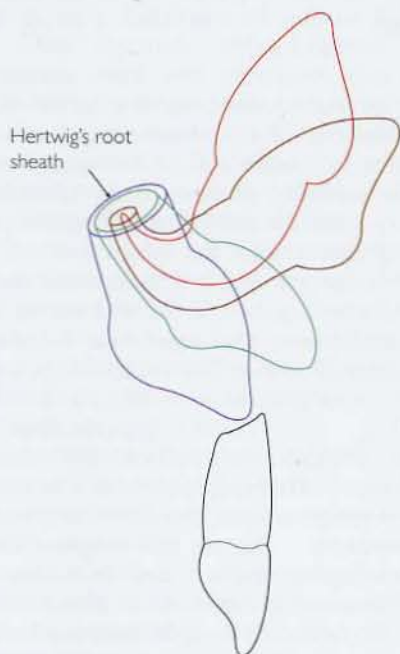


Figure 5.6

A diagrammatic illustration of the progressive alteration in the position of a dilacerated incisor, during unequal root formation. Note that the position of Hertwig's root sheath remains unaltered.

for the typical appearance of the dilacerated tooth, as well as its final unerupted position under the nose. Furthermore, since it may occur with a relatively minor degree of trauma, this could account for the high proportion of cases with no apparent trauma experience. Its relative rarity may be due to a highly critical and specific positional relationship between the deciduous and permanent incisors, at the time of injury. This may account for an absence of bilaterally affected cases, for its non-occurrence among lateral incisors and for an absence of any association with supernumerary teeth, cysts and odontomes.

Arrested root development

When a preschool child suffers a very severe blow to the maxillary anterior dentition, this is likely to result in the loss of the deciduous incisors, and may cause fracture of one or both jaws. The damage to the root-producing ring of cells that forms Hertwig's sheath may have been so serious as to have effectively caused the cessation of any further root development. These teeth may lose their eruption potential, while the adjacent teeth will continue to erupt, bringing with them vertical proliferation of alveolar bone.

Only at a much later stage will this phenomenon be discovered, when the affected tooth or teeth do not erupt and an area of vertically deficient and bucco-palatally narrow, edentulous, alveolar ridge is evident.

Radiographs will usually reveal the crown of the tooth to have a normal axial inclination, but the tooth will be situated very high up in the premaxilla, with minimal or no root formation, depending on how much root had already developed at the time of the accident.

Acute traumatic intrusion (intrusive luxation)

Traumatic injury occurs in young children as the result of play-related activities in school and at home, in accidents involving a fall or, occasionally, as the result of deliberate physical violence (Andreasen and Andreasen, 1994). Effects on the teeth range from a transitory pulp inflammation, through the various

types of fracture of the crown of the tooth and of its root, and, in the severest cases, avulsion of the entire tooth. Intrusion of one or more of the incisor teeth is often associated with a fracture or comminution of the labial plate of bone and a tearing of the periodontal fibres.

A child may present at the emergency clinic with what gives the appearance of a total avulsion, since the tooth is not visible in its former place, the gingiva is lacerated and there is a considerable amount of blood clot. A periapical radiograph of the area will reveal a superior displacement of the tooth, into the alveolar bone, without necessarily producing a fracture of either the crown or the root. The labial plate is displaced labially, although it is most often held close by the injured but uninterrupted band of labial gingiva and soft tissue. The integrity of the blood supply to the soft tissues is usually intact, and this allows good and rapid soft tissue healing.

In a sense, this tooth has been totally avulsed, but in an atypical manner. It is completely displaced from its socket, with a total severance of its attachment apparatus and a disruption of its vital supply lines. When compared with the typical avulsed case, however, it has enormous advantages: the tooth has not been allowed to dry, it has not been in contact with any form of contaminated material, and it is not necessary to store it in saliva or milk or other recommended isotonic medium before restoring it to its former place. It is situated in an area initially surrounded by a coagulating haematoma and later by an organizing blood clot, and it must be assumed that the damaged periodontal fibres in this situation fare considerably better than do those of the replanted tooth, which has spent some time out of the mouth.

DIAGNOSIS

History

The patient's medical history should be recorded carefully. It must be borne in mind that surgical intervention is very likely to be an essential part of the treatment that is to be

provided. Accordingly, such aspects as previous illnesses, particularly rheumatic heart disease, drugs being presently taken and bleeding tendencies, together with any other important and relevant items of information, must be elicited at the outset.

Questions should be asked with particular emphasis placed on the possibility of an episode of trauma. The parent should be questioned carefully to discover whether the child is accident-prone, in general. Direct mention of bicycle accidents, falling from a chair, a ladder or a tree, or being hit in the mouth during play should be made, and all relevant answers should be carefully recorded, together with the approximate dates of their occurrence.

Clinical examination

Much of the dental history is possible to ascertain from a glance at the dentition itself. The existence of sealants and restorations, the absence of teeth, gingival inflammation and the level of oral hygiene will often tell a great deal about past attitudes of both the patient and the attending dentist to prevention and to therapeutic procedures. The presence or absence of the deciduous incisor is generally irrelevant. The central incisor of the opposite side and the lateral incisor of the same side will usually be seen to be tipped towards one another, and there will usually be insufficient space at the occlusal level for the placement of the unerupted tooth. Widely divergent roots of the two adjacent teeth will suggest the presence of an unseen and undiagnosed physical obstruction.

Palpation

In obstructed cases, the unerupted tooth itself is often high on the labial side of the alveolar ridge, and there may be additional and smaller irregularities bulging the alveolus more inferiorly, which are best identified by palpation. There will almost always be a

labio-lingual widening of the ridge. If the ridge area is relatively thin inferiorly, this will indicate that teeth are not present at this level.

The importance of palpation of the area is not to be underestimated, since, if it is not performed with sufficient thoroughness, an important diagnosis may be missed. The presence of a dilacerated central incisor will only be revealed by clinical examination if palpation is made very high in the labial sulcus. Normally, the superior midline area is delineated by the prominence of the anterior nasal spine, on each side of which a shallow depression will be felt. The palatal surface of a dilacerated incisor crown faces forwards and produces a hard swelling in the place where the shallow depression is expected. By superiorly retracting the upper lip, the oral mucosa may be seen to move freely over the stretched area, which will emphasize the outline of the cingulum of the tooth.

Palpation of a dilacerated central incisor may often be made in two places. With the abnormal position of the coronal portion of the tooth, the further development of the root portion may be along an axis that is tipped more lingually, and, in the later stages of root closure, the apex may become palpable as a small and hard lump in the palate. This is a feature that few clinicians seem to look for, and is more consistent than may be realized (Seward, 1968).

Radiographic examination

In Chapter 2, the different methods of radiographically viewing unerupted teeth were discussed in general, and it was pointed out that a periapical view provided essential qualitative information and, as such, should be the first step in this part of the examination.

In the case of an unerupted central incisor, this view will generally show associated pathology with great clarity, including hard tissue obstructions (supernumerary teeth of various types and odontomes), soft tissue lesions (cysts and tumours), and abnormal root and crown morphology of the unerupted

tooth. From this alone, it will usually be possible to establish the reason for the failure of the tooth to erupt.

If supernumerary teeth or odontomes are seen on the film, the information that will then be required relates to their size, their number and their mesio-distal relationship to the midline and the incisor teeth, all of which will be obvious from this view. However, their labio-lingual orientation in relation to the adjacent erupted teeth will not be obvious from this one film. Since the periapical view is obliquely angled to the horizontal plane, a labial supernumerary tooth will appear lower in the vertical plane than a palatal supernumerary that is situated at the same height. Accordingly, the assessment of height is directly related to the labio-lingual position of the tooth.

At the age at which most patients will attend for treatment, a true lateral, tangential view is not helpful, due to the superimposition of central and lateral incisors, deciduous canines and unerupted permanent canines and the supernumerary teeth. A second periapical view, directed from a more distal vantage point, will usually help to localize the relative position of the unerupted teeth, using the principles of parallax. Similarly, a routine (oblique) occlusal film, which we earlier described as a more steeply angled periapical view, will help to separate out the images of the unerupted teeth, using the same parallax principles, this time in the vertical plane. This will then provide the information needed to compute the relative heights of the individual structures.

A good vertex occlusal film, directed through the long axes of the anterior teeth, will provide unequivocal evidence of labio-lingual tooth position, particularly if there is marked displacement.

Dilacerated central incisor teeth with labial displacement have a very special and characteristic appearance on a periapical radiograph. We have already described that the crown and the developed part of the root were rotated labially and superiorly at the time of the trauma or pursuant to it. The long axis of this part of the tooth lies in the direct line of the X-ray beam, which is directed at a periapical

film of the area, and accordingly will show up as a cross-sectional view of the crown, superimposed upon a cross-sectional view of the widest part of the root. The apical (post-trauma) portion of the root, on the other hand, continues to grow roughly along its original course. It will therefore be readily understood that the labial surface will be seen to face superiorly and the cingulum clearly outlined inferiorly. The root apex will be seen as a very short 'tail' extending superiorly above the tooth's labial surface. The picture is reminiscent of a scorpion, viewed from the front.

Although this is clearly recognizable, the film gives only an indication of its height in the alveolus, while its general apico-incisal orientation cannot be defined. Confirmation of the diagnosis may then be positively made, using a tangential or lateral skull radiograph. This will give information that will help to build up a more comprehensive picture of the tooth, particularly regarding details of its morphology, its height and its overall long-axis orientation.

TREATMENT TIMING

In Chapter 1, we discussed the occurrence of a chance pathological finding during routine X-ray examination. Obstructions should be removed wherever possible before they have the chance to create a situation of delayed eruption, in order to obviate the need for orthodontic treatment. There is, however, no preventive treatment to be recommended once trauma has generated the dilaceration, and the patient will need to wait for the time when corrective treatment is appropriate.

When a patient presents with a single central incisor and both lateral incisors erupted, the normal eruption date of the second central incisor will have passed. The impacted tooth will be seen on the periapical radiograph to have at least two-thirds of its root, the developmental landmark that determines that a tooth should be erupted. Orthodontic and surgical treatment are therefore indicated at that time, both for obstructive impactions and for the dilacerated tooth.

Often, at this early stage, one may be able to foresee an obvious need for orthodontic treatment for other reasons – treatment that may not normally be advised until 3 or 4 years later. It is not reasonable to delay the resolution of an impacted central incisor for this period of time merely in the interests of trying to achieve a single-phase orthodontic treatment plan in the full permanent dentition. The alignment of the impacted tooth should be undertaken and executed efficiently, avoiding unnecessary attention to other details. Root uprighting and torquing should be performed as indicated, but an ideal final and artistic alignment is not the aim at this stage.

Once appliances are removed, following the restoration of normality, there will be natural spontaneous changes in the alignment of these teeth during the many months that follow and before the permanent canines come into their place. It must be pointed out to the parent that this is expected to happen, and that it is normal and not a subject for concern. The parent and patient should be advised that further treatment will be necessary at a later date, for the remainder of the overall malocclusion, and that retention of the aligned incisors against these physiological movements is not advised.

ATTITUDES TO TREATMENT

There has been a more or less standard protocol of treatment available for several decades in the orthodontic profession in Europe regarding normally developing but impacted central incisor teeth. The recommendations advise

- (a) that adequate space be prepared for the tooth in the arch, and
- (b) that the cause of the non-eruption (usually a supernumerary tooth) be eliminated.

The impacted central incisor teeth should then usually erupt spontaneously (Battagel, 1985; Houston and Tulley, 1986; Mills, 1987; Mitchell and Bennett, 1992). In the absence of

adequate space, it has been reported that eruption rarely occurs (DiBiase, 1971).

Studies that have been made of patients who have undergone this type of treatment have shown disappointing results with regard to three important parameters.

- 1 *Non-eruption.* Spontaneous eruption has been variously reported as occurring in 54–78% of cases (DiBiase, 1971; Witsenberg and Boering, 1981; Mitchell and Bennett, 1992), which represents a low degree of reliability of the method.
- 2 *Delay in eruption.* Even when eruption occurs, the average time for the affected tooth to make its appearance in the mouth is between 16 and 20 months (Bodenham, 1967; DiBiase, 1971; Mitchell and Bennett, 1992). This is an unacceptably long period of time when one considers that the patient will be without a front tooth or teeth for so many months. Additionally, 25% of the patients needed to have two surgical episodes, followed by a waiting period of 2.5–3 years before the tooth erupted (Mitchell and Bennett, 1992)! In a retrospective study of cases in which (a) space had been provided, (b) the supernumerary tooth had been removed and (c) a stainless steel crown had been cemented to the impacted tooth, eruption was found to have occurred in 96% of the patients. However, this required an average time span of 3 years (Munns, 1981)!
- 3 *Alignment.* The third parameter that showed disappointing results relates to the adequacy of spontaneous alignment. Of the incisor teeth that did erupt (64%) in the study of Mitchell and Bennett (1992), 59% were found to align themselves reasonably well without the use of appliances and 41% required the use of orthodontic appliances to achieve the resolution of rotations and root displacement. According to Gardiner (1961), however, spontaneous alignment occurs only in a minority of patients. Clearly the criteria for deciding what constitutes an acceptable 'alignment' varies from one clinician to another and, one may be per-

mitted to speculate, upon whether the treatment is being carried out in a community health clinic or in a private orthodontic practice.

Some workers (Day, 1964; Kettle, 1958; Hotz, 1961) recognized the need for affirmative action to control (i.e. actively encourage) incisor eruption, and devised methods to perform this, using wire loops and pinning, and even advocated the passing of a wire through a drilled hole in the incisal edge in those early days.

Mills (1987) warned against the exposure of the crown of the permanent tooth during the procedure to remove the supernumerary tooth, warning that periodontal prognosis of the final result would be compromised. Beyond the use of a simple removable appliance to make space in the arch for the unerupted incisor, he displayed a reticence to use mechanotherapy, and seemed to have influenced opinion in Britain, where there appears to be a wide consensus that the use of appliances in bringing down impacted central incisors is something to be avoided. His reasons for this attitude are as follows:

- (a) these teeth often erupt spontaneously, without help;
- (b) loss of labial bony plate;
- (c) poor gingival margin, with less attached gingiva;
- (d) gingival level discrepancy.

Little objective research is offered in support of these contentions, and it is equally open to speculation that most or all of these factors could be adversely affected by over-enthusiastic or otherwise poor surgical technique (Becker et al, 1983; Kohavi et al, 1984). This issue is discussed fully in Chapters 3 and 6.

A minority of children with most other malocclusions are rarely brought to the orthodontist much before 10 or 11 years of age, yet the marred appearance of the child with a single erupted central incisor generally encourages the parent to seek treatment much earlier. An orthodontist's lack of concern for a rapid solution, in response to the parent's disquiet for the child's compromised appear-

ance, is insensitive, if not callous. This is particularly disturbing in the present context, since simple and effective means of achieving this end are freely available.

TREATMENT

Following a determination of the overall orthodontic diagnosis, a problem list should be drawn up. Occasionally, there may be just one item on the list, namely the impacted tooth. More often, the presence of mandibular incisor crowding, posterior crossbite or a class 2 relationship may also be noted, and the clinician must then decide which of these is to be treated in this early treatment phase and which is left until later.

As a general rule, treatment priority should be given to the unerupted incisor, and all other orthodontic procedures delayed until the incisor has been brought into alignment. However, an anterior or posterior crossbite and malalignment of the erupted incisors will usually be treated at the same time as space is being provided for the impacted incisor tooth.

An orthodontic appliance for use in the early mixed dentition

As has been pointed out, opening the space for the unerupted tooth prior to removal of the supernumerary requires some form of orthodontic appliance. The simple removable plate is manifestly unsuitable, since the only positive influence it is capable of producing is a lateral tipping of the adjacent teeth. While this creates space in the arch, it does so only at the coronal level. The effect is quite the opposite more apically, where the roots of the tipped teeth will be moved towards one another and directly into the path of the (it is to be hoped) erupting impacted tooth. Vertical force control on the impacted tooth is difficult to achieve with a removable appliance. Corrective rotatory movement of the finally erupted tooth is rarely adequate, while uprighing and torqueing root movements

are quite impossible. A practitioner using this method would essentially be placed in the seat of an observer, being able to exercise virtually no control over eruption, which is the most important aim of the exercise.

It is true that in the event that the tooth erupts (a) spontaneously and (b) into good alignment there has been much to gain by this relative inactivity, apart from the unreasonable demand on patience that is made of the child, who may be without a front tooth for a very long time.

An impacted tooth initially shares the limited labio-lingual width of the alveolar ridge with the supernumerary tooth, which prevents its eruption. Sharing this space usually causes the root of the central incisor to become displaced in either or both the labio-lingual and mesio-distal planes of space. It is therefore likely that, in the final analysis, the erupting tooth will require root movement in a labio-lingual (torqueing) and/or in a mesio-distal (uprighting) direction, and this may be accompanied by the need for significant rotational movement.

It becomes evident that a completely different type of appliance is indicated – one that has the potential to deal efficiently with all these eventualities. Given the significantly high number of cases where eruption has produced an unsatisfactory alignment or where eruption has failed completely, it is essential to seek an alternative method of mechanotherapy that provides simple and rapid solutions to all the movements required.

A technique must be employed that provides satisfactory answers to the following four aspects:

- 1 The appliance should have the capacity to level and rotate the adjacent teeth rapidly and, with controlled crown and root movements, to open adequate space to accommodate the impacted tooth. This space is demanded both at the occlusal level and for the entire length of the roots of the adjacent teeth.
- 2 The surgical exposure of the crown of the impacted tooth, together with the bonding of an attachment, requires to be performed in a manner that will achieve a

good periodontal prognosis, as described in Chapter 3. The appliance must hold the space during and after the surgical procedure.

- 3 Light and controlled extrusive forces must be generated from the appliance to work over a long range of movement, to bring the tooth down to the occlusal level.
- 4 Final detailing of the position of the impacted tooth and its erupted neighbours must be completed without changing to another appliance, including movement of the crowns and roots of each of these teeth in all three planes of space.

While it is important that the appliance has this facility, we have referred to cases where, at an early stage of dental development, it is not wise to achieve the 'final' alignment of the ideal adult dentition. This is particularly so when the permanent canines are very high and in close relation with the apical third of the lateral incisor roots.

Typically, our young affected patient has two molars and no more than three incisor teeth of the erupted maxillary permanent dentition. The deciduous canines and molars have insufficient crown height and unfavourable anatomy to allow the placement of a fixed multibracketed appliance. Furthermore, there is rarely any need or intention to move them. Accordingly, most practitioners side-step them and band only the molars, with bonded brackets on the incisors, leaving a long span of unsupported wire in the buccal region – the 'two-by-four' appliance.

In the early incisor-aligning stages, the archwire must be of fine gauge. Distortion is difficult to avoid, and consequently the aligning activity of the wire is nullified. Because of the long span, there can be little effective vertically extrusive force directed from the molar tubes, even when the archwire gauge is substantially increased. Anchorage for the extrusive movement of the impacted tooth is therefore poorly exploited, and is limited to the adjacent incisors, which progressively intrude as the treatment proceeds.

Johnson's (modified) twin-wire arch

An updated version of the obsolete and largely forgotten Johnson twin-wire appliance (Johnson, 1934; Shepard, 1961) presents certain unique features that make it especially suitable and efficient in the many treatment aspects of this specific problem, particularly regarding anchorage in the vertical plane.

The appliance is based on fixed molar bands, interconnected by a soldered palatal arch (Fig. 5.7). Long narrow-gauge (0.020"



(a)



(b)

Figure 5.7

(a) An occlusal view of Johnson's (modified) twin-wire arch, to show the soldered palatal arch. (b) 0.020" round tube sections are slotted into the 0.036" round molar tubes. The anterior sectional archwire in this case is a single 0.016" wire, since only one erupted permanent incisor is present and the usual multistranded wire is not needed. The alignment of the buccal tubes shows a downward tip as they proceed mesially, to encourage open bite closure and to aid the mechanically assisted eruption of the impacted tooth.

internal diameter) tubes slide freely in the round molar buccal tubes (0.036"), and are made to extend anteriorly to the deciduous canine area. An initial anterior multistrand sectional wire (0.0175") is held into the long narrow tubes by a friction fit, created by placing three or four bends in the multistranded wire and then drawing it through the tube between two grooved pliers. When the appliance was in general use, several decades ago, and in compliance with its name, two fine 0.010" stainless steel wires were used in the anterior portion, to provide improved flexibility and springiness, which today's multistrand wires achieve to a considerably higher degree.

The first step in the construction of the appliance requires that an impression of the dental arch of the patient is taken, with properly adapted plain molar bands in place. The bands are removed carefully from the teeth and reset into the impression before pouring. On the model, a palatal arch is fabricated and soldered to the lingual side of the molar bands, to provide resistance to the extrusive forces that will be needed later. Buccal tubes are best soldered to ensure precise alignment with the anterior bracket position. Slight upward or downward tipping of the molar tubes, to suit the needs of an individual case (Fig. 5.7b), will create a significant intrusive or extrusive vertical force component on the anterior teeth. The labial archwire is constructed on the model, initially using a multistrand wire in the buccal tubes.

The appliance is transferred to the mouth and cemented in place, brackets are bonded to the anterior teeth, and the prepared initial archwire is placed. The brackets may be of virtually any type, although there are several inherent advantages to Begg brackets in this situation. Their vertical slot makes them particularly suited to the light vertical traction that may need to be applied to encourage the eruption of the impacted tooth.

By the second or third visit, some weeks later, alignment of the three erupted incisor teeth will usually have been achieved, and the multistranded wire is discarded. It is replaced by a plain round stainless steel 0.016" (for Begg) or 0.018" (for Edgewise)

wire, which is similarly inserted in the long narrow-gauge buccal tubes. An expanded coil spring is threaded on it and tied into the anterior portion, compressed between the teeth on either side of the impacted tooth.

Space is gained very rapidly. If edgewise brackets are used, the movement will be at least partly by tipping, and subsequent uprighting will need to be performed with a heavier gauge wire or using auxilliary springs. Once there is adequate room for the unerupted tooth and uprighting has been achieved, a piece of stainless steel tubing should be threaded onto the archwire, the length of the tube being cut so that it fits exactly between the brackets of the teeth adjacent to the impacted tooth. The presence of the tubing between the adjacent teeth ensures maintenance of the required space and contributes to the rigidity of the archwire. This in turn provides a firm platform from which light force may be applied to the unerupted tooth.

At this point, the patient is ready for the surgical episode, in which the retained deciduous incisor and buried supernumerary tooth are removed. The permanent incisor is exposed and an attachment placed. All this is achieved without removing any part of the orthodontic appliance.

If the patient is seen every 14–21 days for adjustment, a previously obstructed tooth will usually erupt very rapidly, and within weeks it will be visible, to provide the young patient with a more acceptable appearance, which will enhance his or her self-confidence and self-image. The favourable time factor is an advantage that should not be underestimated and one that needs to be taken into account, even when treating the younger patient. A dilacerated incisor will take longer to resolve, but the treatment principles are the same (Figs 5.8 and 5.9).

At the point when the tooth reaches the occlusal level, a reassessment is made as to whether uprighting, torqueing or rotation of the tooth is needed. If so, the eyelet is removed and a bracket similar to that on the other teeth is placed in its ideal position. Finishing is then achieved in the appropriate manner (Fig. 5.10).

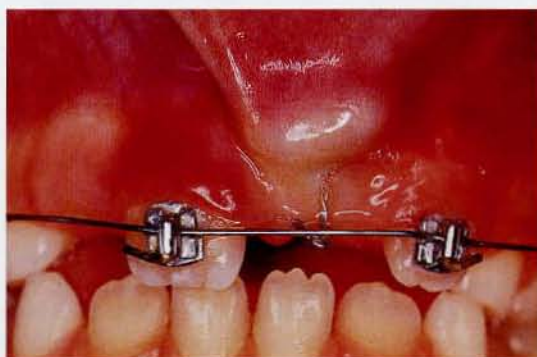


Figure 5.8

A different patient is shown here to illustrate surgical exposure and attachment bonding after adequate space has been reopened.



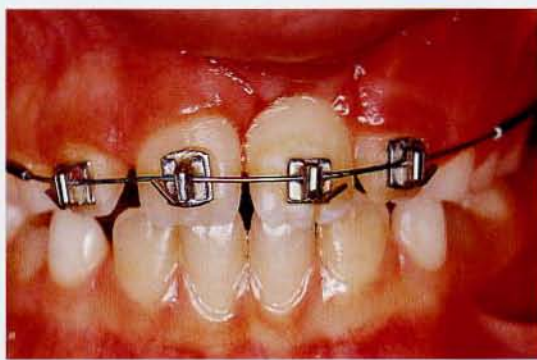
(a)



(b)



(c)



(d)

Figure 5.9

(a) Full engagement of the wire in the bracket increases the vertical traction component. (b) 4.5 months post-surgery, following three visits for adjustment, the impacted central incisor is palpable more inferiorly. A bracket has been placed on the newly erupted lateral incisor. (c) 9 months post-surgery, the tooth is well erupted and labially displaced and rotated. (d) 11.5 months post-surgery, adequate alignment has been achieved.

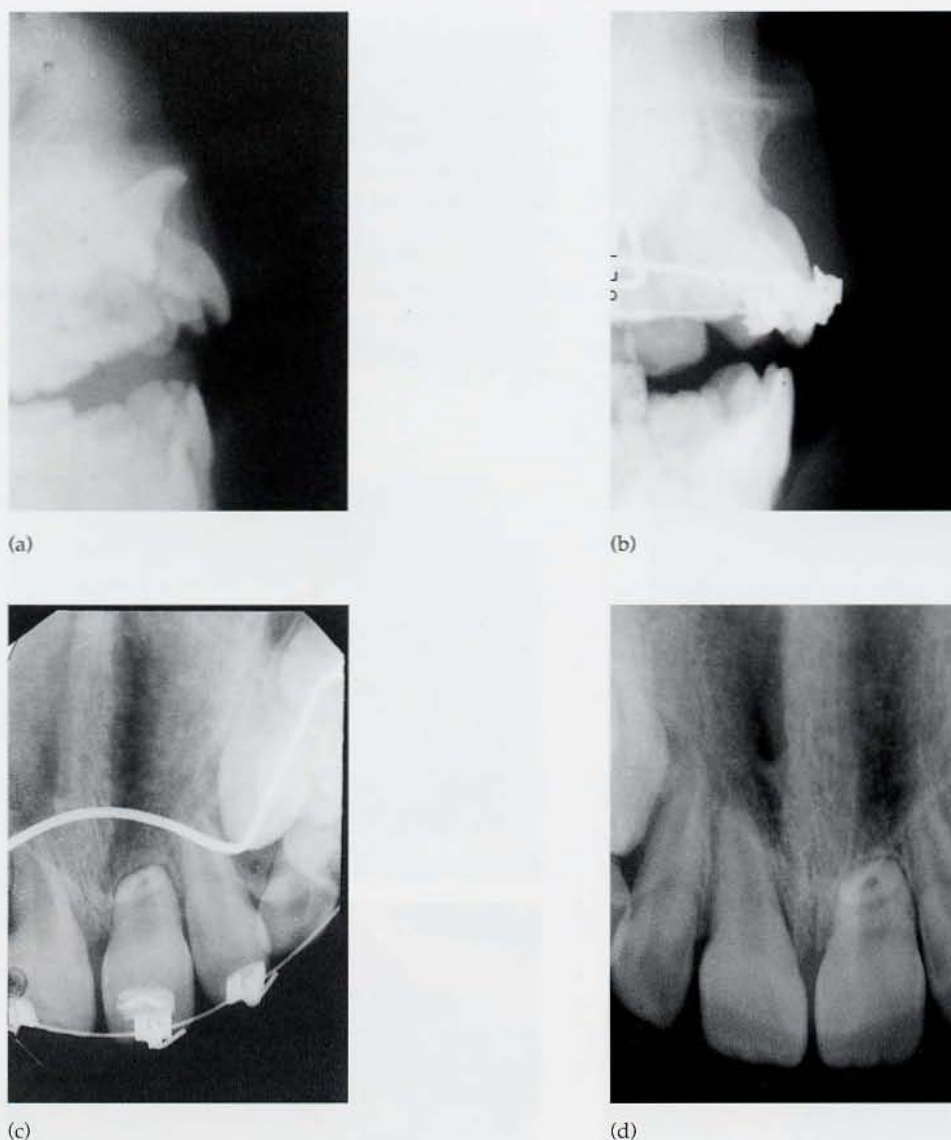


Figure 5.10

(a,b) Tangential views of the anterior maxilla of case illustrated in Figs 5.7 and 5.9 to show the case before and after treatment. (c) The periapical view of the case immediately prior to appliance removal. Careful examination of the root of the previously impacted left central incisor will reveal that the apical third of the root is parallel to the central X-ray beam. The root may be of normal length. (d) The periapical view 14 months after completion of treatment.

The orthodontic treatment procedure is very simple, and does not require a high level of expertise. The laboratory stage of appliance construction requires accurate soldering of the palatal arch and careful alignment of the

buccal tubes, which a good orthodontic technician should master very quickly, although the orthodontist may prefer to do this himself or herself. In the mouth, cementation of the bands and bonding of the brackets is routine,

and the application of the prepared archwire presents a neat and robust appliance in the long span between the molar tubes and the incisor brackets, while anteriorly providing light and gentle vertically directed forces of good range, to give rapid results. The presence of the palatal arch will ensure that undesired movement of the adjacent incisors and the distant anchor molars cannot occur.

In common with other patients with unerupted incisors, the patient with arrested root development will usually seek advice and treatment before the age of 9 years. By

contrast, however, in these cases more than one and occasionally all the maxillary incisors may have been similarly affected. While the principles of treatment are the same as for the patients we have already discussed, it is clear that, in the most severe of cases, even a partially bracketed fixed appliance may be inappropriate.

In order to overcome the problem, a heavy buccal archwire of 0.036" (0.9 mm) gauge may be fitted into similar-gauge round tubes on molar bands carrying a soldered palatal arch (Fig. 5.11).



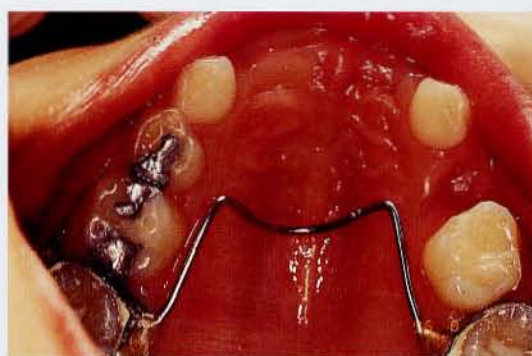
(a)



(b)



(c)



(d)

Figure 5.11

(a) This 9-year-old child has lost alveolar bone height after avulsing his anterior deciduous teeth at age 2 years in an accident. (b, c) The panoramic and lateral cephalometric films show very little root development of all maxillary incisors. The central incisors are at the level of the anterior nasal spine. (d) View of soldered palatal arch. (e) The incisors are surgically exposed. Note the large areas of hypoplastic enamel. (f) Eyelet attachments are bonded. (g) After suturing, a self-supporting 'stopped' labial archwire is



(e)



(f)



(g)



(h)



(i)



(j)

placed into the molar tubes. Displaced superiorly by gentle finger pressure, the anterior part of the archwire is ensnared by all four steel pigtails, to deliver extrusive force. (h, i) Tangential and anterior occlusal radiographic views immediately post-surgery. (j) A clinical view at completion of treatment.

(Figure 5.11 continued)

(Figure 5.11 continued)



(k)



(l)

(k, l) Periapical and tangential radiographs at completion of treatment. Note poor development, anatomical form and life expectancy of the teeth at the end of treatment. Uprighting of the roots was considered inappropriate.

At the completion of this phase of treatment, and for all of the types of problem described here, it is good practice to perform a reassessment of the overall orthodontic condition. Further treatment may be advised at this stage, as mentioned earlier. More frequently, however, the appliance is removed and the patient is placed on recall over a period of several years until the eruption of the full permanent dentition, when a new clinical assessment is made and an overall treatment plan is developed for the entire dentition.

PROGNOSIS

The obstructed impaction

The prognosis of the result is dependent on several factors.

Root length

The root length is almost always normal in impacted teeth, although in some cases the root may be somewhat shorter, owing to the cramped circumstances in which the root developed, prior to treatment. Nevertheless, a mild degree of shortening will not normally adversely affect prognosis.

Type and height of periodontal attachment

If the surgeon opened a window in the oral mucosa directly over the impacted tooth, above the attached gingiva, then the prognosis of the result will be relatively poor. Steps should be taken to manage the muco-gingival soft tissue properly, by lifting a full flap from the crest of the ridge at the time of the surgical exposure and fully resuturing the wound, at the end. In this way, the tooth will come down with a normal band of attached gingiva, and the periodontal result will be good.

Relative bone height of the crestal alveolus

In Chapter 6, we shall show that when teeth are super-erupted, their vertical movement is

accompanied by a vertical increase in the alveolar bone associated with them. Thus, when the impaction of a tooth is resolved by augmenting the natural eruptive force, following the removal of the causative agent, it will be seen that the bone support of that tooth will be greater than that around normally erupting adjacent teeth (Ingber, 1974, 1976; Stern and Becker, 1980; Kohavi et al, 1984; Melsen, 1986). However, this positive response on the part of the alveolar bone to the extrusive forces is dependent on the amount of pressure applied being within relatively narrow limits. A periapical radiograph taken at that time will show radiolucent areas where new bone is being laid down – new bone does not show up on X-ray. However, a similar view taken 4–6 months after cessation of this movement, when the bone will have matured and calcified, will show the excellence of its regeneration.

In the event that excessive extrusive force is brought to bear on these teeth, eruption will also occur rapidly, but it will occur without regeneration of alveolar bone. The result will be characterized by the tooth having a long clinical crown and considerable mobility. A periapical radiograph performed even 6 months later will show a much reduced bone level around the newly and apparently successfully resolved impaction. The prognosis of such a tooth will be impaired.

Preservation of vitality

During the surgical procedure, removal of awkwardly placed supernumerary teeth may cause devitalization of the impacted tooth. This is quite unusual, however, and it is more likely that excessive extrusive forces, which may be negligently applied to erupt the tooth. This compromises its bony support, and will also bring about the demise of its pulpal tissue.

Oral hygiene

During the initial phase of eruption of an impacted tooth, the surrounding gingiva is

sensitive, tender and bleeds very easily. This will usually make the younger patient very apprehensive of brushing the area on a regular basis and to an adequate standard of cleanliness. Secondary inflammation of the gingiva and a concurrent adverse effect on the regeneration of bone will be the inevitable result.

For these reasons, care should be taken in the proper planning and execution of the surgical technique and in the application of extrusive forces whose magnitude are difficult to control. Elastic ligation thread is used widely for applying traction to impacted teeth, by tying it directly and tightly between attachment and a relatively rigid archwire. It is exceptionally difficult to properly judge the amount of force being applied by this method, and so, when it is the only practical one available, great care should be taken not to tie too tightly. Wherever possible, alternative methods should be used, as described in Chapter 4.

Vertical 'box' elastics are often used in orthodontics to enhance intercuspation at the close of treatment, in routine cases. These elastics are small and can produce forces very much in excess of that desirable for a single impacted tooth, and these will be increased still further by mouth opening. It is difficult to measure or control the forces applied in this way. Nevertheless, this is a valuable tool, and should be used with only the very lightest and largest of elastics. It should also be remembered that, as orthodontists, we are apt to apply more than adequate extrusive forces by the downward deflection of an archwire, and we then place a 'box' elastic, in addition, just to be sure! The aggregated force becomes very much in excess of the physiological limit.

Impaction due to trauma

Soft tissue obstruction

The only treatment needed to overcome the resistance of the thickened mucosa to eruption is surgical, and was described in Chapter 3.

The dilacerated central incisor tooth and the incisor with arrested root development

It is clear that the long-term prognosis of many dilacerated teeth and teeth with arrested root development is poor and their extraction and replacement is probably a part of the long-term treatment strategy. This being so, the most pertinent of questions that needs to be asked regarding the dilacerated tooth is whether it is worth it.

The answer to the question is not necessarily the same for every case, and each must be considered on its own merits. No decision should be made until the practitioner first considers the following points in relation to the particular patient concerned.

- (a) A permanent artificial solution cannot be considered much before early adulthood, whether by conventional prosthodontic treatment or implant-borne restoration.
- (b) Any tissue-borne form of temporary replacement (partial 'flipper' denture) will be far less satisfactory from every point of view.
- (c) Any tooth-borne, resin-bonded bridge replacement may require some preparation of the adjacent teeth, and may be unreliable in the long term (Boyer and Williams, 1993).
- (d) Following the extraction of the dilacerated tooth, the alveolar ridge area is deficient both vertically and in its labio-lingual width, making the case unsuitable for an implant and unaesthetic for a conventional bridge.
- (e) Orthodontic alignment of the dilacerated tooth will bring with it much alveolar bone, to enhance both ridge width and vertical height, to normal dimensions.
- (f) The retention of even a very short-rooted and endodontically treated tooth will preserve the normal shape and architecture of the alveolar ridge.

Under these conditions, orthodontic alignment of the impacted and dilacerated tooth will usually be preferable, even if splinting of this compromised tooth is needed to give it support. For the most part, however, this procedure must be looked upon as providing

only a temporary solution, and, at a later time, when growth has ceased and conditions are more favourable, some form of permanent restoration will need to be considered.

Apical root dilaceration

In the very young patient, treatment of the dilacerated incisor follows much the same lines as described for the obstructed incisor. Before this is done, however, a careful study of the tangential radiograph may reveal the shape and orientation of the root. The more apical the dilaceration vis-à-vis the coronal third of the root, the better the prognosis. On the other hand, if the dilaceration is in the crown of the tooth, the prognosis improves the closer it is to the incisal edge.

If the dilaceration is situated apical to the coronal third of the root, orthodontic alignment will provide an excellent prognosis. The tooth should be surgically exposed and an eyelet bonded to it. In most cases, the only surface of the crown that is available for the eyelet is the palatal surface. This faces the operator when the tooth is first exposed, while the anatomically labial surface of the tooth is inaccessible, facing superiorly and posteriorly and buried in the hard tissue of the anterior nasal spine (Fig. 5.8).

A stainless steel ligature is threaded through the eyelet, twisted into a pigtail and drawn downwards, to be ligated to the main archwire with a horizontal elastomeric module, as described in Chapter 4. Care should be taken not to apply much pressure initially, since the tension introduced by suturing the surgical flap may itself apply a considerable downward force to the tooth in the first few weeks.

As the crown of the tooth responds to the force, it rotates downwards more and more. At the same time, the root apex rotates forwards towards the labial plate of bone. In general, the case may be completed without the root apex ever becoming palpable in the labial sulcus. Only in exceptional circumstances, when the root curvature is very acute, will this possibility become a reality.

If the apex is prominent and further labial root movement is still desirable, this will necessitate a surgical intervention, performed

with the aim of amputating the root apex of this tooth. The labially directed portion of the root, corresponding to the post-traumatic developmental portion, is sectioned in a line that is continuous with the labial side of the main coronal portion of the root of the tooth. The pulp is extirpated and the root canal is obliterated using a combined conventional (coronal) and retrograde endodontic approach, wherever possible (Fig. 5.12). Further extrusion and appropriate root torqueing of the incisor may necessitate a second root-shortening procedure, but, if the first procedure was delayed as late as possible and the root apex amputation was properly designed, this may usually be avoided.

The degree by which the final prognosis of the short-rooted central incisor will be compromised depends largely on how much root remains after the amputation has been performed. The site of the amputation is entirely dependent on the location of the dilaceration, and it eliminates a majority of that portion of the root, apical to it, that had developed after the traumatic episode. Thus the closer the dilaceration is to the coronal portion of the root, the shorter will be the final root length at the completion of treatment and the poorer its prognosis.

Crown dilaceration

Dilaceration may also occur in the crown portion of the tooth, as has been indicated earlier. In this eventuality, the tooth itself may not be so seriously displaced labially. When the crown is surgically exposed, an attachment is best placed on the labial surface, which is almost certainly accessible. In this way, the continued downwards-directed orthodontic traction will bring the root portion of the tooth from its more palatally displaced location, close to its normal position and its long axis within normal limits. This will be due to the lingual tipping effect of the attachment on the labial surface. The tooth will erupt with the more incisal section of its crown labially tipped and the post-traumatic section in an acceptable angulation.

Restorative treatment is indicated after grinding off that portion of the crown that

represents the pre-trauma dental developmental portion. The future of the tooth will then be founded on the majority portion of the tooth, which developed subsequent to the traumatic episode. Root canal treatment may be required and the ideal contour of the tooth restored using a crown and core restoration. Rarely, the dilaceration site may be found to be very incisally placed, in which case a more modest composite material restoration may be used, with vitality maintained. In either case, the initial crown reconstruction that is placed should be made in a line continuous with the long axis of the root portion and an orthodontic bracket bonded to its appropriate mid-labial position, ready for finishing. Final root alignment, in both the labio-lingual and mesio-distal planes, is then achieved in the usual manner for the particular appliance system being used.

Dilaceration of the coronal third of the root

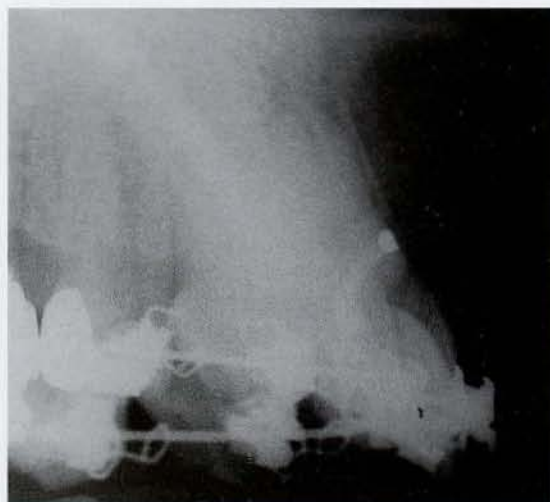
The critical portion of the tooth for the dilaceration to occur is the coronal part of the root,

close to the cemento-enamel junction. In this situation, the prognosis of the aligned tooth is extremely poor, since the majority of its root, that relating to the post-trauma period of development, will need to be amputated during the procedure, leaving the tooth with a non-viable coronal remnant of the root. Such a tooth will need to be extracted. Nevertheless, it will be necessary to reopen the space in the dental arch for some form of artificial replacement. Accordingly and regardless of the prognosis, the same preparatory orthodontic procedure is still advisable.

A modified Johnson's twin-wire arch may be placed and space opened up as accurately as possible, to provide exactly the right amount, by comparing it with its erupted antimer. At this point, the dilacerated tooth is exposed, and, if its condition is confirmed as hopeless, it may be extracted, but not discarded! Instead, its contorted root is carefully severed from the perfectly shaped crown with a high-speed diamond bur, and the pulp chamber cleaned and filled with a composite filling material. The newly prepared natural



(a)



(b)

Figure 5.12

Tangential views of the completed alignment of a dilacerated tooth with root canal filling (a) prior to and (b) after apicectomy and retrograde amalgam filling. (Courtesy of Dr I Heling & Dr M Morag.)



(a)



(b)

Figure 5.13

(a) Precisely measured re-opening of the space is performed, using a removable appliance. (b) The prepared crown of the dilacerate central incisor, shown in Fig. 5.4, is bonded between the etched interproximal surfaces of the adjacent teeth.

crown may then be bonded to the two adjacent teeth, to act as its own space maintainer (Becker et al, 1976), until a more satisfactory permanent replacement may be made, which, in view of the patient's age, may not be for several years (Fig. 5.13).

Alternatively, and provided that the apical portion of the root is substantial, it may be advantageous to treat it in the manner of a crown dilaceration. To achieve this, it will be necessary to remove the crown of the tooth at the time of surgical exposure and to perform an immediate root canal filling. A fixed, threaded post is prepared and a small hole is bored through its coronal end. The post is then firmly placed. The root surface and much of the coronal part of the post are covered with a composite filling material, leaving the tip of the post exposed. A stainless steel ligature wire is passed through the prepared hole and lightly twisted into a pigtail with the help of artery forceps. In the absence of the acutely angled crown portion, the remainder of the tooth presents a less complicated impaction, whose resolution is straightforward.

The prepared tooth is erupted into the mouth until the post and the restoration covering the root surface become apparent at the gingival level. The orientation of the root of the tooth is then reassessed by palpation and by taking new radiographs – a periapical for

the mesio-distal inclination and a tangential for the bucco-lingual relationship. The latter view will be considerably easier to discern than before, since the root canal filling will act as an excellent radio-opaque marker.

The patient is now referred for any necessary and appropriate muco-gingival surgery by a competent periodontist, followed by the construction of a good quality temporary acrylic crown, which is placed over the existing post. A general dentist or a specialist prosthodontist is familiar with the need for 'correcting' an abnormal root orientation by placing the artificial crown in line with the crowns of the adjacent teeth, regardless of the root axis. This may be a sensible compromise in the more minor non-impacted displacement cases, since orthodontic root movement may then be avoided. However, in dilaceration cases, considerable root movement is needed, and this is most suitably performed with the existing orthodontic appliance. For this to be made possible, the temporary crown must be placed at an angulation appropriate to the recently confirmed long-axis orientation of the root. The desired orientation of this intended reconstruction of the crown of the tooth will not be in line with its neighbours, and this is not always an easy message to convey to the prosthodontist! Once the temporary artificial restoration is in place, a bracket is placed in the usual manner. Crown

alignment and root torque and uprighting are then undertaken.

It may be seen that the point beyond which a root amputation should be avoided is when less than one-third of the root will remain after treatment. Crown amputation may be used as a viable alternative up to that point, but it must be remembered that the remaining root portion, which may be as little as one-half to two-thirds its original length, will be narrower in both mesio-distal and buccolingual dimensions, which will make the placement of a satisfactory crown more difficult to achieve.

It is emphasized that, once the space in the arch has been gained and the time has come for surgical exposure, accurate diagnosis of the exact location of the dilaceration is critical if a valid decision is to be made. As pointed out earlier, this is not always possible from the radiographs, owing to the superimposition of other unerupted teeth and neighbouring roots on the tangential view. The periapical view can contribute nothing in this respect.

If it is still impossible to locate the dilaceration then an attachment should be placed on the lingual side of the tooth, as before, and the initial traction applied to bring the crown of the tooth occlusally. A decision to amputate the root portion of the tooth must, in any case, be delayed until the root is palpable, bulging into the labial sulcus. At each subsequent visit, the sulcus should be carefully checked, and any palpable change in the position of the root apex in this direction should be compared with the downward progress and eruption status of the crown and its angulation. Progress radiographs should be taken at appropriate stages, until the exact location of the dilaceration may be pinpointed or otherwise clinically diagnosed, particularly in relation to the long axes of the two parts of the tooth. Once the accurate diagnosis has been established, a reassessment of the treatment approach should be made to decide whether the line of treatment is indeed appropriate or whether the crown portion should be amputated and the direction of traction altered accordingly.

ACUTE TRAUMATIC INTRUSIVE LUXATION

Following traumatic intrusive luxation, the affected tooth may re-erupt and may eventually return to its original position (Shapira et al, 1986). In other cases, however, the tooth remains intruded and may require orthodontic assistance to encourage re-eruption. For these cases, the emergency treatment and some initial restorative procedures will already have been carried out by the paedodontist or the oral surgeon, and the patient will not be in pain at the time that orthodontic assistance is required.

For this tooth to 'take' and be successful, the desired union of tooth to the surrounding bone is by healing alone or by healing with surface resorption. According to Andreasen and Andreasen (1994), healing without surface resorption is probably not a possibility in the clinical situation, since it must be completed totally without injury to the innermost layer of the periodontal ligament. However, healing with surface resorption will leave the luxated tooth attached to the socket with a normal periodontal ligament and new cementum. Such a tooth will respond to orthodontic forces.

If, on the other hand, healing is by replacement resorption, there is a direct union between the root and the surrounding bone. Repair will be counted as successful, but the tooth will then never be amenable to orthodontic forces. The tooth may sometimes regain a normal attachment (a transient replacement resorption), although this is by no means certain, and it is probably more likely that areas of ankylosis will occur over the root surface and the tooth will then remain intruded permanently. The tooth, as it stands, is then of no value to the dentition, nor is it useful as a foundation for lasting prosthodontic restoration. Under these conditions, its extraction will be indicated.

Orthodontic intervention at the appropriate time may offer the only viable treatment option that, together with certain relatively minor restorative procedures, may produce an excellent result with a fair prognosis. If the tooth is still completely subgingival then the



Figure 5.14

(a) Acute intrusion of a maxillary left and crown fracture of the maxillary right central incisors. (b) The tangential radiograph shows intrusive and buccal displacement. (c) At 14 days post-trauma, a button attachment is bonded to the intruded incisor. The labial arch is activated to extrude the tooth and the patient is instructed in accurate placement and care. (d,e) The tooth has re-erupted. Both central incisors have had root canal treatment and crown restoration. (Courtesy of Dr B Peretz.)

labial soft tissue will need to be superiorly repositioned, until 2 mm of the incisal edge of the tooth is revealed. Light extrusive force must be applied after the time that the periodontal fibres have begun to re-unite and in the earlier stages of the organization of the blood clot, but before the laying down of bone, i.e. 10–28 days post-trauma.

Special care must be exercised when using fixed appliances in this situation (Andreasen and Andreasen, 1994). First, with or without

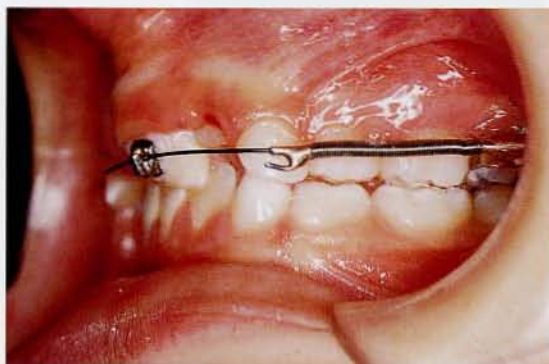
the use of orthodontic brackets, some kind of resistant framework needs to be bonded to the adjacent teeth, which act as a multiple anchor unit from which force would be applied to the intruded tooth. This could take the form of a few brackets and an archwire, although the composite bonding of wire directly to the labial enamel of these teeth would be more satisfactory from many points of view. Unfortunately, these teeth themselves will almost certainly have been



(a)



(b)



(c)



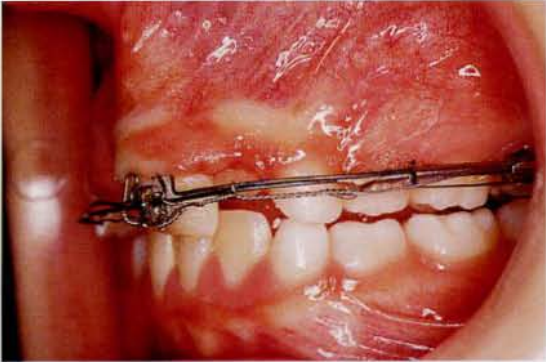
(d)

Figure 5.15

(a,b) Front and left views, showing palatally displaced central incisor, 1 week post-trauma. The crown reduction is clearly seen. (c,d) Modified Johnson's twin-arch appliance in place. Buccal coil springs apply labial tipping force on the single 0.018" archwire, which engages the bracket of the displaced tooth. (e,f) A torqueing auxiliary is laced down to the main archwire and tied back to the molar tubes. (g–i) 12 months after completion of treatment: front and left views of the occlusion and a close-up view of the maxillary central incisor teeth. (j,k) Tangential and periapical pretreatment views. (l,m) Tangential and periapical views 4 weeks later. (n) Periapical view at 12 months shows obliterating vital pulp.



(e)



(f)



(g)



(h)



(i)

(Figure 5.15 continued)

(Figure 5.15 continued)



(j)



(l)



(k)



(m)



(n)

traumatized at the time of the accident, and using them in this manner may lead to further damage, even at the light force levels involved. Secondly, if the intended extrusion is performed more than 2 months post-trauma, ankylosis may have affected the target tooth (Andreasen and Andreasen, 1994). Active extrusive forces generated by the appliance will then be of no avail. Instead, the reactive forces will be absorbed by the adjacent anchor teeth, and these will become intruded.

Simple removable appliances (Fig. 5.14) are most suitable, since they need apply no force to the adjacent teeth, which may also have been damaged in the traumatic experience (Peretz et al, 1982; Mamber, 1994). A small button attachment is bonded on the labial side of the tooth and the labial bow of the removable appliance is divided at the midline and activated vertically downwards against the button. Treatment generally proceeds rapidly, with the tooth appearing in the mouth and at the level of its neighbours within a few weeks, depending on the amount of extrusion required. Once the tooth erupts, root canal therapy is usually needed, and a permanent restoration may be placed, followed by a short period of retention.

Intruded teeth whose root development is completed are generally scheduled for root treatment in the first week after the traumatic incident. Under ideal circumstances, orthodontic treatment of endodontically treated teeth is not normally advised until they have been followed up for several months and until there is some radiographic evidence of repair. However, following intrusive trauma, the possibility of the occurrence of ankylosis (replacement resorption) is significant, and will be evident within two months. Thus the exceptional circumstances dictate that the orthodontic extrusion of these teeth must begin, at the latest, six weeks or so after the traumatic episode, although the 10–28-day time frame is to be preferred. The risk of failure of extrusion due to replacement resorption is high and absolute, which is why treatment should begin within this time. The risk of an orthodontically induced need for root treatment is much lower and of less therapeutic significance.

Once the tooth has been brought into alignment, it may be retained and splinted to its immediate neighbours, using a short length of multistranded wire, which is bonded to the labial surface of the three teeth, for a few months only. It is important not to cover the wire completely with composite material, but to place a small blob of composite material across the wire over each tooth and to leave broad areas of exposed and flexible wire. Rigid bonding for long periods is contraindicated, since it seems to lead to a greater incidence of pulp necrosis and pulp obliteration (Andreasen and Vestergaard Pedersen, 1985; Rock and Grundy, 1981). However, the multistranded wire splint allows a degree of movement, which is similar in extent to that seen in physiological mobility (Becker, 1987; Becker and Goultschin, 1984; Zachrisson, 1977; Dahl and Zachrisson, 1991), and thus may probably be safely used for considerably longer. Appropriate restoration may be undertaken before or after this splinting has been completed.

A child may sustain a severe blow to the premaxillary area, displacing a maxillary central incisor in such a way that the crown is tipped inwards and the root protrudes through the alveolar bone. The patient is unable to close the teeth together, owing to prematurity on the displaced tooth. In the heat of the moment and lacking suitable direction, the parents of a child do not always attend the appropriate clinic or the most knowledgeable dental practitioner.

The emergency treatment indicated for this case is to manipulate the tooth to its original site, under local anaesthetic and to splint it in place. The patient shown in Fig. 5.15 was treated by grinding the incisor to reduce the occlusal interference, and was given a bite plate to disarticulate the teeth! When the parent was finally referred elsewhere, several days had elapsed and manipulative reduction of the displacement was no longer appropriate. Orthodontic treatment was prescribed to resite the tooth by applying labial tipping and then palatal root torque. Since this involved its being moved through freshly organizing blood clot, the treatment proceeded with great speed. The tooth maintained its vitality, as

evidenced by positive pulp testing and by pulp obliteration. Finally, the ground-down crown was improved with a composite restoration, and follow-up periapical radiography will determine whether root resorption occurs and if appropriate root canal therapy will be needed.

REFERENCES

- Andreasen JO, Andreasen FM (1994) *Textbook and Color Atlas of Traumatic Injuries to the Teeth*. Munksgaard, Copenhagen.
- Andreasen RM, Verstergaard Pedersen B (1985) Prognosis of luxated permanent teeth – the development of pulp necrosis. *Endod Dent Traumatol* 1: 207–20.
- Battagel J (1985) The case for early assessment: 2: treatment with specialist support. *Dental Update* 12: 293–8.
- Becker A (1987) Periodontal splinting with multistrand wire following orthodontic realignment of migrated teeth: report of 38 cases. *Intl J Adult Orthod Orthogn Surg* 2: 99–109.
- Becker A, Goultschin J (1984) The multistrand retainer and splint. *Am J Orthod* 85: 470–4.
- Becker A, Stern N, Zelcer Z (1976) Utilization of a dilacerated incisor tooth as its own space maintainer. *J Dent* 4: 263–4.
- Becker A, Kohavi D, Zilberman Y (1983) Periodontal status following the alignment of palatally impacted canine teeth. *Am J Orthod* 84: 332–6.
- Bodenham RS (1967) The treatment and prognosis of unerupted maxillary incisors, associated with the presence of supernumerary teeth. *Br Dent J* 123: 173–7.
- Boyer DB, Williams VD, Thayer KE (1993) Analysis of debond rates of resin-bonded prostheses. *J Dent Res* 72: 1244–8.
- Brin I, Zilberman Y, Azaz B (1982) The unerupted maxillary central incisor: review of its etiology and treatment. *J Dent Child* 43: 352–6.
- Brook AH (1974) Dental anomalies of number, form and size: their prevalence in British schoolchildren. *J Int Assoc Dent Child* 5: 37–53.
- Dahl EH, Zachrisson B (1991) Long-term experience with direct-bonded lingual retainers. *J Clin Orthod* 25: 619–30.
- Day RCB (1964) Supernumerary teeth in the premaxillary region. *Br Dent J* 116: 304–8.
- Di Biase DD (1971) The effects of variations in tooth morphology and position on eruption. *Dent Pract Dent Rec* 22: 95–108.
- Gardiner JH (1961) Supernumerary teeth. *Dent Pract Dent Rec* 12: 63–73.
- Hotz R (1961) *Orthodontia in Everyday Practice*. Huber, Berne.
- Houston WJB, Tulley WJ (1986) *A Textbook of Orthodontics*, pp 126–31. Wright, Bristol.
- Howard RD (1967) The unerupted incisor. *Dent Pract Dent Rec* 17: 332–42.
- Howe GL (1971) *Minor Oral Surgery*, 2nd edn, pp 135–7. Wright, Bristol.
- Ingber SJ (1974) Forced eruption. Part I. A method of treating isolated one and two wall infrabony osseous defects – rationale and case report. *J Period* 45: 199–206.
- Ingber SJ (1976) Forced eruption. Part II. A method of treating non-restorable teeth – periodontal and restorative considerations. *J Period* 47: 203–16.
- Johnson JE (1934) A new orthodontic mechanism: the twin wire alignment appliance. *Internat J Orthod* 20: 946–63.
- Kettle MA (1958) Unerupted upper incisors. *Trans Eur Orthod Soc* 34: 388–95.
- Kohavi D, Becker A, Zilberman Y (1984) Surgical exposure, orthodontic movement and final tooth position as factors in periodontal breakdown of treated palatally impacted canines. *Am J Orthod* 85: 72–7.
- Mamber EK (1994) Treatment of intruded

permanent incisors: a multidisciplinary approach. *Endod Dent Traumatol* 10: 98-104.

Melsen B (1986) Tissue reaction following application of extrusive and intrusive forces to teeth in adult monkeys. *Am J Orthod* 89: 469-75.

Mills JRE (1987) *Principles and Practice of Orthodontics*, 2nd edn. Churchill Livingstone, Edinburgh.

Mitchell L, Bennett TG (1992) Supernumerary teeth causing delayed eruption - a retrospective study. *Br J Orthod* 19: 41-6.

Munns D (1981) Unerupted incisors. *Br J Orthod* 8: 39-42.

Peretz B, Becker A, Chosak A (1982) The repositioning of a traumatically-intruded mature rooted permanent incisor with a removable appliance. *J Pedodont* 6: 343-54.

Rock WP, Grundy MC (1981) The effect of luxation and subluxation upon the prognosis of traumatized incisor teeth. *J Dent* 9: 224-30.

Seward GR (1968) Radiology in general dental practice. IX - Unerupted maxillary canines, central incisors and supernumeraries. *Br Dent J* 115: 85-91.

Shapira J, Regev L, Liebfeld H (1986) Re-eruption of completely intruded immature permanent incisors. *Endod Dent Traumatol* 2: 113-16.

Shepard ES (1961) *Technique and Treatment with the Twin-Wire Appliance* Mosby, St Louis.

Stern N, Becker A (1980) Forced eruption: biological and clinical considerations. *J Oral Rehabil* 7: 395-402.

Stewart DJ (1978) Dilacerate unerupted maxillary central incisors. *Br Dent J* 145: 229-33.

Tay F, Pang A, Yuen S (1984) Unerupted maxillary anterior supernumerary teeth: report of 204 cases. *J Dent Child* 51: 289-94.

Witsenberg B, Boering G (1981) Eruption of impacted permanent upper incisor teeth after removal of supernumerary teeth. *J Oral Surg* 10: 423-31.

Zachrisson BU (1977) Clinical experience with direct-bonded orthodontic retainers. *Am J Orthod* 71: 440-8.

Zilberman Y, Malron M, Shteyer A (1992) Assessment of 100 children in Jerusalem with supernumerary teeth in the premaxillary region. *J Dent Child* 59: 44-7.

6 PALATALLY IMPACTED CANINES

CONTENTS • Prevalence • Aetiology • Complications of the untreated impacted canine • Diagnosis • Treatment timing • General principles of mechanotherapy • The need for classification of the palatal canine • A classification of palatally impacted canines

PREVALENCE

In any population, the prevalence of palatally impacted maxillary canines is low, but it seems to have a variable distribution with regard to ethnic origin. The lowest frequency reported in the literature relates to the Japanese (Takahama and Aiyama, 1982), where the anomaly occurred in only 0.27% of the sample population. Some very early studies by Cramer (1929) among white Americans and Mead (1930) in an undefined sample found 1.4% and 1.57% respectively. A study of a large series of full mouth dental radiographs among patients in the USA revealed a figure of 0.92% (Dachi and Howell, 1961), while Brin et al (1986), in a study of an Israeli population, found a level of 1.5%. The highest figure for the anomaly found in the more recent surveys, 1.8%, has been reported in the study by Thilander and Jacobson (1968), of an Icelandic population.

Montelius (1932) was the first to indicate a difference between Caucasian and Oriental populations, although he found a frequency of 1.7% for Chinese and 5.9% for Caucasians. However, since he did not distinguish between buccal and palatal impaction in his

study, little useful information may be gleaned from these figures in the immediate context. More recently, the work of Oliver et al (1989) has indirectly indicated that Asians may suffer from buccally impacted canines more frequently than from palatal canines. While this appears to be supported by various case reports that have appeared in the literature from the Far East, no definitive study has been undertaken to investigate this possibility.

A strong prevalence of impacted canines is found among females, with a ratio of 2.3 : 1 (Dachi and Howell, 1961) in the above-mentioned group of American patients, 2.5 : 1 (Becker et al, 1981) in an Israeli orthodontic group, and 3 : 1 in both a Welsh orthodontic group (Oliver et al, 1989) and in a US orthodontic sample (Johnston, 1969).

However, some confusion exists with regard to these figures, since a random Israeli population study (Brin et al, 1986) has shown an approximately equal male-female occurrence of the anomaly. Furthermore, Oliver et al (1989) have indicated that, although a higher female incidence was present in their study of Welsh patients, this reflected the trend for more females to seek orthodontic treatment in the UK.



(a)

Figure 6.1

(a) Anterior occlusal view shows an impacted canine, an odontome and a missing lateral incisor. (b) Periapical view of impacted canine and first premolar associated with an odontome and over-retained deciduous first molar.



(b)

If we are to assume that the motivation for this is that girls are more concerned with improving their appearance than the diagnosis of an impacted maxillary canine, given the presence of an over-retained deciduous canine, is not usually the cause for the patient presenting for orthodontic treatment. Appearance is rarely marred by this, since there is a complete and uninterrupted display of teeth, and any abnormalities are usually not disfiguring. Motivation for treatment may therefore rather depend on the ability and persuasiveness of a particular practitioner in pointing out the potential hazards of non-treatment. There may be no basis to expect that this would convince more female patients than males to accept treatment.

AETIOLOGY

There is no single cause of the palatal displacement of the maxillary canine tooth. Space-occupying, extraneous entities of den-

tal origin (Fig. 6.1) will undoubtedly produce abnormal positioning of an unerupted permanent maxillary canine, but they are comparatively rare in the canine area. The fact that the majority of impacted canines occur in their absence compels us to look elsewhere for the main causes of impaction.

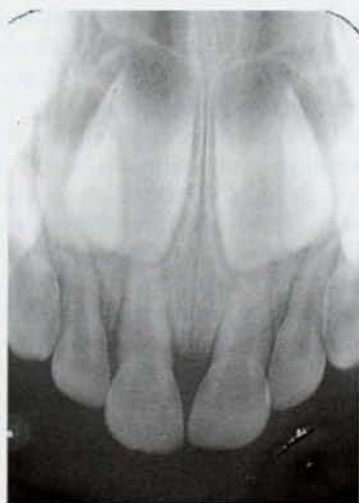
To explain the mechanism of palatal displacement of the maxillary canine, some of the hypotheses that have been put forward have been intimately involved with aberration in the normal process by which the maxillary anterior teeth erupt. For this reason, an understanding of normal development in this area is important

Normal development

In the middle period of the deciduous dentition, a periapical radiograph of the premaxillary region will show the fully completed deciduous incisor roots. It will show the overlapping shadows of the permanent central

and lateral incisors, more or less in the same horizontal plane (Fig. 6.2a) as the apical half of the roots of the deciduous incisors, with the canines being sited higher up. The overlap of the permanent teeth crowns is due to the fact that these relatively wide permanent teeth are all contained in a narrow area and,

at this time, are initially located palatally in the alveolus. The developmental position of the lateral incisors is palatal with relation to both the central incisors and to the permanent canines. For these reasons, the periapical view described above gives the appearance of severe crowding.



(a)



(b)



(c)

Figure 6.2

(a) A periapical view of maxillary permanent incisor, at age 3 years. Note the degree of overlap of unerupted permanent central and lateral incisors. (b) The same patient at 5 years. The permanent central incisors have migrated inferiorly and labially relative to the lateral incisors. Note the reduced degree of incisor overlap. (c) The central incisors are erupting at age 6.5 years. Note how the lateral incisors have migrated labially into the arch to eliminate the overlap completely. (Courtesy of Dr B Peretz.)

During the early eruptive movements of the central incisors, a progressive resorption of the roots of the deciduous incisors occurs. The permanent incisors migrate slowly across from the palatal side of the arch to the labial, as they proceed in their downward path, until the teeth erupt into a more labial perimeter than was defined by the deciduous incisor teeth before their shedding. During this process, the wide crown portion of the central incisors will have moved downwards and labially (Fig. 6.2b). As this occurs, the progressively narrower CEJ area and then root portion of the central incisor come to lie mesial to the unerupted lateral incisor crowns. This leads to the fairly rapid provision of space at this level in the alveolus (Friel, 1949). The lateral incisor migrates labially into this area as it begins its downward eruption path. Additionally, the downward eruption movement distances it from the permanent canine crown, providing more space for it to move labially, following closely behind the central incisor.

With the eruption of the central incisors, the lateral incisor crowns move from a lingual relationship into a direct distal relationship with the central incisor roots, initially at a higher level (Fig. 6.2c). As this occurs, the presence of the lateral incisor crowns displaces the developing apical area of the central incisors towards one another, since these are at the same level, within the alveolar bone. With the central incisor apices held together in this way, the crowns of these teeth are flared distally. A developmentally normal median diastema is thus produced, which has been termed the 'ugly duckling' (Broadbent, 1941).

A year or so later, the lateral incisors will have descended along the distal side of the central incisor roots, to release their 'hold' on the narrowed inter-apical width of the central incisor roots, allowing the roots to drift apart. The lateral incisors continue to move inferiorly along their eruptive path, progressively reducing their constricting influence on the central incisor roots until they reach the distal side of the necks of the central incisor crowns. At this point, their presence and continued downward migration serves to provide a

mesially directed force to the crowns of these teeth, moving them towards one another and partially closing off the median diastema. The long axes of the central incisor teeth will also have changed, with the roots becoming more parallel. The lateral incisor long axes, however, are relatively flared in the coronal direction, with their root apices close to those of the central incisors.

A periapical view of the area at this time will show the unerupted permanent canine crowns, of each side, pointing mesially towards the lateral incisor apical area. They appear to be the containing influence that causes the apical convergence of the incisor roots and the reason that the median diastema has not completely closed. Subsequent follow-up radiographs of the area will show the permanent canine altering its relationship as it moves downwards along the distal side of the root of the lateral incisor, uprighting the long axis of that tooth. The canine's own long axis becomes more vertical as it progresses and as the root of the deciduous canine becomes resorbed. With the shedding of the deciduous canine, it finally erupts with a slight mesial inclination, taking up its place in the arch by moving the crowns of the incisors towards the midline, to close off the diastema completely (Becker, 1978). As all this occurs, the long axes of the incisor teeth change from being apically convergent to become more parallel and even slightly divergent.

Throughout the period of its downward progress, the permanent canine is conspicuously palpable on the buccal side of the alveolar ridge, from as early as 2 or 3 years prior to its normal eruption, which normally occurs at the age of 11-13 years.

Theories regarding the causes of palatal displacement

Long path of eruption

From the early days of Broadbent, in the 1940s, the most common reason given for palatal displacement of the permanent maxil-

lary canine was the fact that it had a long and tortuous eruption path, beginning close to the floor of the orbit. It was considered that this tooth had much further to travel before it erupted into the mouth and that it therefore had a greater chance of 'losing its way'. This has been standard teaching for many years.

Crowding

Hitchin (1956) considered that crowding of the dentition was the reason for this condition, although he offered no evidence to support his contention.

In general, crowding of the dentition results in the exaggerated displacement of a tooth from its developmental position in the arch. The developmental position of the maxillary lateral incisor is lingual to the line of the arch, as we have already described above. Thus, when crowding affects the early mixed dentition, there will be insufficient space for the lateral incisor to migrate labially between the root of the central incisor and the deciduous canine teeth, which is the manner in which it normally comes into the dental arch. It therefore continues to develop downwards, but in a lingual position, and erupts lingual to the adjacent teeth.

A parallel environment is created when a second deciduous maxillary molar is extracted before its due time, and the first permanent molar drifts mesially into the available space. Similarly to the lateral incisor, the developing second premolar develops palatally to the line of the arch, and its continued development and eruptive path will be in an exaggerated palatal direction, in much the same way.

We have pointed out above that the normal eruption path of the permanent canine is buccal to the line of the arch, and we also know that the lateral incisor and first premolar, the teeth immediately adjacent to the canine, erupt before the canine. Thus, in the presence of crowding, there will be reduced space in the arch in the canine area, and the close proximity of these adjacent teeth will prevent the canine from moving into the arch. The vertical development of the maxillary permanent canine will therefore be accompanied by its buccal displacement, to give the typical picture seen in the class 1 crowded case (Fig. 6.3). Whether the tooth eventually erupts or remains impacted is irrelevant, although buccal impaction is most unusual.

It is therefore quite clear that the cause of this type of displacement of the canine is



Figure 6.3

Buccally displaced maxillary canines due to a crowded arch.

completely different from that involved with palatal displacement. The two conditions are different entities. They should never be confused, nor should they be lumped together to form an experimental group for clinical research, as if to offer a homogeneous sample of impacted teeth. For the purposes of study, it is far more logical to combine all palatally displaced canines, whether they are unerupted or erupted, since they share a common aetiology, although their clinical presentation may be different.

In a series of more recent clinical research studies, Jacoby (1983), Becker (1984) and Brin et al (1986) have pointed out that the likelihood of palatal displacement is much reduced where crowding is present. On the contrary, they have shown it to be a far more prevalent occurrence when there is excessive space in the dental arch.

Non-resorption of the root of the deciduous canine

Lappin (1951) considered that it was the failure of the root of the deciduous canine to resorb that caused a palatal deflection of the eruption path of the permanent canine, leading to its impaction.

Here, too, one may draw a parallel with other teeth. In cases where a second deciduous molar is over-retained, owing to the presence of a malposed tooth germ, one may often see on the periapical or panoramic radiograph that one of the roots has totally resorbed, while the second root is only partially so. The long spicule of unresorbed root that may be present retains the tooth against natural shedding, while the fully developed and unerupted second premolar is situated immediately beneath the crown of the deciduous tooth, in the area previously occupied by the resorbed portion of the roots.

From this type of clinical evidence, which is seen so widely and frequently in practice, it is generally considered that the presence and advancing eruption of the permanent tooth provides the stimulus for the resorption, and a portion of root distant from the unerupted permanent tooth may be unaffected by this process. On the basis of this, Lappin's view

would appear to be 'putting the cart before the horse'.

Nevertheless, and in support of his argument, subsequent studies (Howard, 1967; Ericson and Kurol 1988c; Lindauer et al, 1992; Power and Short, 1993) have shown the spontaneous eruption of previously impacted canines in many cases, following the extraction of deciduous canines. This will be discussed at length later in this chapter, under the heading 'Preventive treatment and its timing'.

Trauma

In a recent clinical report Brin et al (1993b) have illustrated how trauma, which leads to a cessation in the development of a lateral incisor root, may be associated with palatal canine impaction. They explain this by assuming that

- (a) the traumatic episode may have caused movement of the lateral incisor, or
- (b) by conduction, movement of the unerupted canine itself, or
- (c) in terms of the guidance theory, this is due to the shortness of the lateral incisor root, whose development ceased as the result of the trauma.

A further alternative could place the blame on the possible presence of chronic irritation or residual infection around the apex of a non-vital deciduous canine tooth (Fig. 6.4), which may equally have produced the deflected path of eruption, as pointed out by Fearne and Lee (1988).

The guidance theory

Miller (1963) and Bass (1967) reported that there appeared to be an unusually high prevalence of congenitally missing lateral incisors associated with palatally impacted canine teeth. They theorized that, under these circumstances, the permanent canine lacks the guidance normally afforded by the distal aspect of the lateral incisor root. As pointed out earlier, in relation to normal development, the canine initially has a strong mesial developmental path, which alters early on,

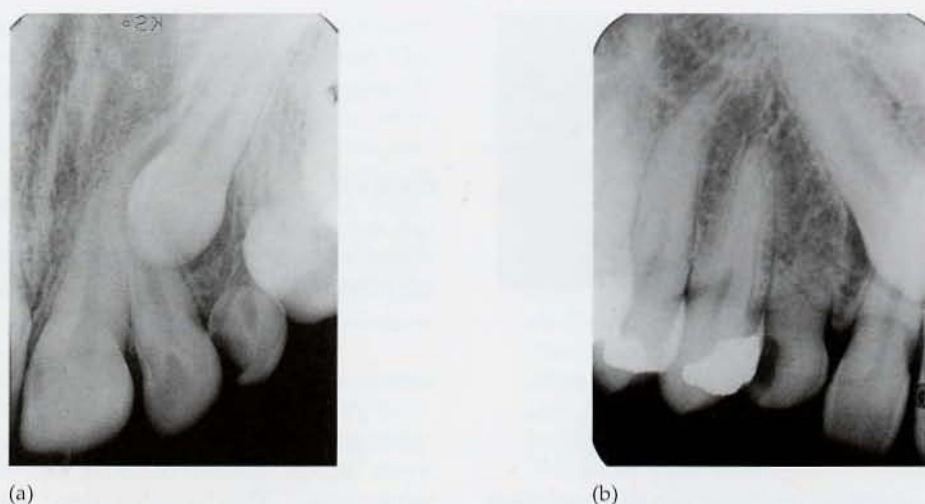


Figure 6.4

(a, b) Periapical views of two impacted canines, each associated with a non-vital deciduous canine.

with the canine being guided downwards, apparently along the distal aspect of the lateral incisor root. They concluded that, in the absence of this guiding influence, the canine continues in its initial mesial and palatal path. The tooth then becomes impacted in the palatal area, posterior to the central incisors, and fails to erupt in its due time, if at all.

Miller's concept was founded on information gleaned from the study of six such cases. He assumed that, since a peg-shaped or otherwise abnormally small lateral incisor develops a root of more or less normal length, such a tooth would provide the required guidance for the normal eruption of its adjacent canine. He therefore rationalized that these anomalous teeth could not be an aetiological factor in canine impaction.

Following the treatment of several hundred cases of this type by the present author, a different pattern of association seemed apparent. Palatal impaction of the maxillary canine appeared to be intimately bound up with the occurrence of anomalous lateral incisors and less with the congenitally missing teeth.

Furthermore, a stereotype of the maxillary impacted canine patient could be offered (Fig. 6.5), in which the patient is frequently a 15-year-old female, with well-aligned and normally related dental arches, slight spacing and no real malocclusion. Characteristically, the teeth are small, the lateral incisors particularly so, there may be missing teeth, dental development is late and the patient's motivation for treatment is low.

A series of clinical research studies followed, in which a sample of patients who were successfully treated for a palatally displaced canine was studied. In the first study (Becker et al, 1981), a wide and highly significant discrepancy in the numbers of normal, small and peg-shaped lateral incisors adjacent to an affected canine was found, compared with the published data for normal populations. In the interests of accuracy, a random study was later performed by the same research group (Brin et al, 1986) to quantify the various types of lateral incisors found within the general population of the same geographic area, while using the same defini-



Figure 6.5

Late developing dentition showing spacing, small peg-shaped lateral incisors, teeth of poor anatomical contour and minor Class I malocclusion.

tions of anomaly. In the general population, 93% of all lateral incisor teeth were of normal shape and size, compared with only 52% in the palatal canine sample. In the random population sample, missing lateral incisors were found in approximately 1% of the cases, which contrasted markedly with the 5.5% of this anomaly among the impacted canine cases, or 5 times as frequently.

These results clearly support the concept of Miller and of Bass regarding the part played by the lateral incisor as a guide in the normal eruption of the permanent canine. Without this guidance, normal eruption is compromised fivefold.

However, Miller's rationalization regarding the positive role of anomalous lateral incisors appears very much misplaced. Small lateral incisors were seen in only 4% of the random sample, while the palatal canine cases showed this anomaly to be 8 times as frequent (25%). Furthermore, only 2% of the general population had peg-shaped incisors, while 17% (9 times the frequency) were seen among the palatal canine cases. Similar results have since been shown in confirmatory studies that have examined Welsh (Oliver et al, 1989) and west of Scotland (Mossey et al, 1994) samples.

Were small or peg-shaped lateral incisors to have played a positive role of any sort, as outlined in the guidance theory, then one would expect figures lower than 5.5%. Their presence is shown here to offer more than merely a loss of guidance to the developing perma-

nent canine. The fact that they increase the chance for impaction to almost twice that of the missing lateral suggests that an additional, obstructive role is played by these teeth.

In the first study (Becker et al, 1981), a hypothesis was presented based on the fact that the anomalous small and peg-shaped lateral incisors develop very much later than normal lateral incisors. While no figures are available for the extent of this delay, it seems clear from clinical observation that it may be as much as 3 years – and this for teeth whose calcification normally begins at age 10–12 months!

If we are now to relate this to the 'guidance theory of impaction', we may postulate that at the critical time that the permanent canine requires the guidance, the root of the anomalous lateral incisor is too rudimentarily developed to provide it. Thus initially the situation is parallel to that seen in congenital lateral incisor absence. The result is that the canine develops mesially and palatally and usually in a downwards direction, into the vertical alveolar process, where it proceeds towards the palatal periosteum. This describes the first stage of palatal displacement.

The palatal periosteum may then halt further progress of the tooth, or it may alter the eruption path to a more horizontal direction, across the palate. In either instance, this may then be defined as a first-stage palatal impaction.

Alternatively, the palatal periosteum may guide the developing canine downwards. The alveolar process in the canine region is V-shaped in cross-section, such that, with continued vertical movement, the progressively narrowing alveolus will tend to guide the aberrant canine in a buccal/labial direction. These corrective movements of the palatally displaced canine are the characteristic feature of what may be termed the first stage of palatal displacement with secondary correction (Figs 6.6a–d).

In cases of congenital absence of the lateral incisor, a canine that was not palpable buccally at any point in its earlier development may often be seen to finally erupt more mesially than normal and in the line of the arch. In the presence of an over-retained deciduous lateral incisor or canine only, the corrective movements of the canine lead to the initiation of root resorption. Following the shedding of the deciduous tooth or teeth, the permanent canine may then erupt into the line of the arch.

If a late-developing lateral incisor is present, it will now lie directly in the path of the displaced canine. The physical presence of the lateral incisor will bring an abrupt stop to these corrective movements, and any further vertical development of the canine may only then be on the palatal side of the dental arch, completing the second stage of palatal displacement.

In summary, therefore, the 'guidance theory' comprises five elements.

- 1 *Normal eruption.* It adopts Broadbent's original view that, given the timely and normal development of a lateral incisor, guidance for the canine is provided and a buccal path of eruption is to be expected, with the tooth palpable early on.
- 2 *First-stage impaction.* It offers an explanation for the loss of guidance at a critical time in the normal development of the permanent canine, which leads to a deflection of the developmental path of the tooth, causing it to move palatally. This aetiological factor may be created by a congenitally missing lateral incisor or by a late-developing, anomalous lateral

incisor. In the event that no vertical movement of the canine into the alveolar process occurs, the result may be a horizontal palatal impaction.

- 3 *First-stage impaction with secondary correction.* It goes on to explain the corrective influence of the vertical alveolar process, which redirects the canine on a more favourable path. This scenario may be difficult to diagnose accurately, and the clinician must draw his or her own conclusions from the further progress of the impacted tooth, which may be palpable, low down on the palatal side, before it finally erupts close to the line of the arch. The tooth may then spontaneously move more buccally, in the absence of a lateral incisor, to reach the occlusal plane in a close-to-normal bucco-lingual position.
- 4 *Second-stage impaction.* Self-correction is prevented by the presence of an anomalous and late-developing lateral incisor, redeflecting the tooth further palatally. This may be termed second-stage displacement, and is an aetiological factor that is not seen where the lateral incisor is absent.
- 5 *Second-stage impaction with secondary correction.* As we shall see later, in the discussion of treatment timing, extraction of a deciduous canine, or even the lateral incisor itself, may often lead to spontaneous eruption of the impacted tooth.

Small, peg-shaped and missing teeth are more frequent findings among females than among males, in the ratio of 2:1. Furthermore, the maxillary permanent canine erupts earlier in females, which could mean that earlier lateral incisor guidance will be necessary for its normal eruption. These facts provide the hypothesis with some support in explaining why palatal canines are more frequent in females and why anomalous lateral incisors are a more powerful causal agent than congenitally absent lateral incisors.

It is quite clear that heredity plays an important role in this hypothesis. The assumption is that the genetically determined factors (small, peg-shaped, missing lateral incisors, etc.) provide an environment that



(a)



(b)



(c)



(d)

Figure 6.6

(a-d) Serial radiographs showing the relationship of an unerupted canine to a late-developing and peg-shaped lateral incisor. (d) The two teeth have erupted and are superimposed on one another. At clinical examination, both erupted canines were found to be on the palatal side.

leads to a loss of guidance of the canine, its abnormal palatal path and impaction.

Heredity

Given the strong hereditary influence in palatal canine displacement, there are those who believe that this is the principal factor involved and dismiss other relationships as secondary or as similarly linked hereditary factors. In other words, the palatal canine is another link in the chain of genetically linked phenomena.

In a study of the families of children affected by palatally displaced maxillary canines (Zilberman et al, 1990), a search was made among the parents and the siblings for the related anomalies to which we have referred above. The prevalence of small, peg-shaped and missing lateral incisors, late-developing dentitions and other missing teeth among these close relatives was very high, in addition to palatally impacted canines.

This evidence points to heredity as the causal agent for these associated phenomena. We have contended that their presence cre-

ates an environment favourable to the development of palatally displaced canines, and, as was to be expected, this phenomenon was found to occur in an unusually high proportion of these cases. The view that these phenomena are each genetically determined, including the canine displacement, and frequently occur together (Bjerklin et al, 1992; Peck et al, 1994, 1995), is equally tenable, but would appear to be an oversimplification. The fact that the extraction of adjacent deciduous canines or anomalous lateral incisors greatly improves the chances of canine eruption would lead us to believe that local factors cannot be ignored as exerting a powerful influence on the aetiology of canine impaction.

Peck et al (1994) have studied the transposition of maxillary permanent canine and first premolar (Fig. 6.7), and have found a strong hereditary influence in its aetiology. Since this type of condition of the canines cannot be construed as deriving from guidance from the lateral incisor, and cannot be influenced in any way by the size, form or timing of the development of that tooth, this has been used



Figure 6.7

Maxillary canine/first premolar transposition. An example of hereditary primary tooth germ displacement.

as a model to refute the 'guidance theory'. However, there is no basis for comparing transposition with palatal displacement, rendering the comparison invalid (Becker, 1995).

Other forms of maxillary canine positional anomaly do occur from time to time, which are difficult to equate with the more usual pattern of palatal or buccal displacement. Genetic factors seem likely to be the governing factors, in which the entire tooth is located in an abnormal position. In these cases, it seems that the original site or orientation of the anlage, from which the tooth developed, was abnormal. Thus we occasionally come across patients in whom there is adequate space in the arch for the ideal eruption and alignment of the maxillary permanent canines, yet these teeth erupt buccally ectopic (Fig. 6.8). Additionally, the eruption occurs relatively high in the alveolus and the tooth has no mesio-distal contact with its immediate neighbours. This represents an anomaly analogous to the canine-first premolar transposition cases (Peck et al, 1993), although its expression is much milder.

It is clear that there is a particular genetic factor that has produced these unusual and very specific canine locations (Fig. 6.9). This is quite different from the more frequent buccally placed canine, which is the product of crowding, and its position is dictated by the amount of space available for it in the arch and by a direct interproximal contact with the adjacent teeth.

We may prefer to define this rare condition as primary tooth-germ displacement, in order to distinguish it from other and more common forms of displacement, which have an environmentally influenced aetiology.

The vast majority of palatally displaced canines show the root apex to be ideally placed, in the line of the arch (Becker, 1995). Experience shows that extrusion and tipping of the crown into its place in the arch is usually sufficient, with little or no root torque being required in most cases. This indicates where the tooth 'is coming from', and it is reasonable to assume that local causes have been instrumental in its deflected path of eruption.

COMPLICATIONS OF THE UNTREATED IMPACTED CANINE

Morbidity of the deciduous canine

Early morbidity of the deciduous canine is common for two reasons. First, its root may become markedly resorbed, creating considerable mobility and eventual shedding, without the possibility of replacement by the permanent tooth. This creates a problem in terms of restoration, since the space is usually too small for a satisfactory replacement either by the misplaced permanent canine or by some form of artificial fixed bridge pontic or implant.

The second reason that such a tooth may not survive relates to its relatively high susceptibility to interproximal (particularly distal) caries. In Israel, it is still common to see a fairly extensive distal cavity in this tooth at around the age of 11 or 12 onwards, which may have been deliberately left untreated by



Figure 6.8

The canine has developed in an abnormal location, representing another example of primary tooth germ displacement.



(a)



(b)

Figure 6.9

(a,b) Bilateral primary tooth germ displacement seen on panoramic and lateral skull films. The condition is under genetic control.

a general practitioner who was unaware of the likelihood or existence of impaction of its permanent successor.

Cystic change

Loss of vitality may occur very early on in the carious process, in the deciduous canine teeth owing to the narrowness of the hard structures of these teeth and the relatively large pulp. Necrosis of the pulp and periapical pathology may be asymptomatic.

Under these circumstances, there may be a direct interconnection between the apical pathology and the follicular sac surrounding the impacted canine. This may stimulate an enlargement of the follicular sac, which is clearly seen on a periapical radiograph. It may also undergo cystic change, to produce a dentigerous cyst (Fig. 6.10). This may also occur without any relation to pathosis of the deciduous canine. In strictly radiological terms, an enlargement of the follicular sac to beyond 2 or 3 mm is generally considered to represent cystic change. In rare cases, these

**Figure 6.10**

A dentigerous cyst surrounds the crown of an impacted canine.

cysts may expand at the expense of surrounding maxillary bone and displace the canine higher and higher in the maxilla, as has been described in Chapter 1.

Alternatively, and rarely, the chronic periapical lesion on the deciduous canine may itself become cystic – a radicular cyst – and its subsequent enlargement may displace the adjacent teeth, including the palatal canine.

Crown resorption

The reduced enamel epithelium surrounding the completed crown of a tooth may degenerate with age, and its integrity may be lost.



Figure 6.11

Periapical view of maxillary incisor area in a 63-year-old female, showing advanced resorption of the crowns of two impacted canines. The follicles of both teeth are almost completely absent, and the teeth are very radiolucent, with poor definition.

This allows bone and connective tissue to come into direct contact with the crown of the tooth, and osteoclastic activity will lead to resorption of the enamel and its replacement by bone – a process known as replacement resorption. Over a long period of time, repeated radiographs of the tooth will show the enamel becoming less and less contrasting in density, highlighting this bone-for-enamel substitution (Fig. 6.11). Subsequent surgical exposure of the crown of this tooth will show a pitted surface, which is difficult to separate from the surrounding hard and sparse soft tissues.

This finding seems more likely to occur in adult patients in whom the impaction has been left untreated over two or three decades (Azaz and Shteyer, 1978).

Resorption of the lateral incisor root

Little is known about the reasons for the resorption of the roots of deciduous teeth that leads to their eventual shedding and why this does not normally occur with the roots of permanent teeth. Nevertheless, the proximity of the follicular sac of an unerupted permanent tooth to the roots of its deciduous predecessor appears to be the trigger that initiates the process of root resorption, probably as the result of pressure. The continuity of this resorption process is then maintained by the further advance of the eruption of the permanent tooth, which moves into new areas vacated by the resorbing root.

Under certain conditions, however, the presence of an unerupted permanent canine tooth may lead to the resorption of the root of the adjacent lateral (Fig. 6.12) or central incisor. Furthermore, and in a manner similar to that seen with deciduous teeth, the progress of this undesirable phenomenon depends on further eruptive movements on the part of the impacted tooth. If the impacted tooth is removed or its path redirected, the resorption process usually ceases.

In this context, it is perhaps pertinent to comment that the maxillary canine, which is the only permanent tooth whose eruption

may cause resorption of the roots of neighbouring teeth to any significant degree, is also the only permanent tooth that normally develops in close relationship with the developing apical areas of the roots of other permanent teeth. The premolar teeth develop in a restricted area, encompassed by the roots of the deciduous molars and at a distance from other permanent teeth. The central incisors and first molars erupt before their adjacent neighbours, and the lateral incisor is related to the neck area of the crown of the central incisor. The canine, however, is closely related to the roots of the adjacent lateral incisor and first premolar, while it is still fairly high in the maxilla during most of its eruption period.

Marked resorption of the lateral incisor root is not common and only a minority of impacted canines seem to be associated with

it (Ericson and Kurol, 1987a,b, 1988a). When it occurs, however, its onset may be rapid and its conduct aggressive (Brin et al, 1993a). An indelible impression is usually left on the operator who has to deal with this eventuality. Thus early identification of the presence of lateral incisor root resorption is important in order not to delay the commencement of treatment to a time when the survival of an important adjacent tooth may be threatened. For this reason, while extra-oral radiographic views of the impacted tooth may offer the best means of locating its position accurately, a good periapical view should always be taken and studied, with this possibility in mind.

It should be remembered, however, that only resorption of the apical or interproximal surfaces of the root of the lateral incisor will be visible on the periapical radiograph. Given that the impacted canine is most frequently related to the palatal surface of the root of the incisor, it is clear that many areas of resorption of this aspect of the root surface will escape recognition, often until they are in a fairly advanced stage, using conventional radiography. The use of computed tomography (CT) is the only available method for discovering root resorption of the palatal or buccal aspects of the root of a tooth (Ericson and Kurol, 1988b).

Several studies have been conducted to try to identify those lateral incisors that are most liable to be afflicted by root resorption. These have largely researched parameters concerning the impacted tooth, such as the size of the follicular sac and cystic change, none of which have shown any correlation with root resorption.

Earlier in this chapter, the aetiological link between palatal canines and anomalous lateral incisors was discussed. It was pointed out that, in a sample of patients with impacted canines, almost half of the adjacent lateral incisors were anomalous. The same group of researchers (Brin et al, 1993a) tested the occurrence of root resorption against the various categories of lateral incisor (normal, small and peg-shaped), to see if any one of them was more susceptible than the others. A strong correlation of the occurrence of resorp-



Figure 6.12

The impacted canine crown is surrounded by a large dentigerous cyst, and there is associated root resorption of both the deciduous canine (to be expected) and the permanent lateral incisor (pathological).

tion with those patients whose lateral incisors were normal in size was found. While resorption of the lateral incisor root has been shown to occur in 12% of cases in the 10–13-year-old age group (Ericson and Kurol, 1987a), when it does, it is far more common in a normally sized lateral incisor than with a small or peg-shaped lateral incisor. When a normally sized lateral incisor is associated with an adjacent palatally impacted canine, the chances of resorption of its root are 7 times greater than if the lateral incisor is small or peg-shaped!

DIAGNOSIS

Unerrupted permanent maxillary canines cause the patient relatively few problems, unlike the impacted mandibular third molar. A retained deciduous canine may have a relatively poor appearance compared with a properly aligned permanent canine, but most patients do not seek treatment for the retained deciduous canine. The discovery of palatal impaction is therefore usually made by the general dentist, at the time of routine dental examination.

Inspection

The maxillary permanent canine normally erupts at a dental age of about 11 years. Its non-appearance at this age should invite clinical inspection and radiographic investigation, especially if its antimere is present.

The maxillary incisor teeth are normally flared laterally and spaced until the age of 10 years, as described earlier. Should this situation still be true by 11 or 12 years, the clinician should be suspicious, since this means that there is a detail missing from the mechanism that smoothly transfers the ugly duckling stage into the final adult alignment, with interproximal incisor contacts. Indeed, a resultant persistent median diastema may be the factor that brings the patient to the office, unaware of the impacted canine, to request treatment.

It is unlikely that a missing lateral incisor or a frankly peg-shaped incisor will be overlooked. Nevertheless, care should be taken to examine the size and shape of existing lateral incisors. Central and lateral incisors whose crowns have mesio-distal straight or slightly tapering sides and lack the classical proximal contour are usually small teeth and often develop late. Some of these are peg-shaped, a condition defined by their widest mesio-distal dimension being at the CEJ.

Furthermore, the discovery of a late-developing dentition and a dentition in which there are missing teeth, other than the lateral incisors, should also be treated with a degree of caution. All these factors have been linked with palatally displaced canines, and this possibility should be thoroughly investigated, both at the time when the phenomena are first noticed and in subsequent follow-up examinations that have been scheduled to oversee the smooth changeover from the mixed to the permanent dentitions.

Abnormally positioned and unerrupted canines frequently affect the positions of neighbouring teeth, particularly lateral incisors. We have already pointed out that the root of the canine is usually in the line of the arch, with the crown mesially displaced, in addition to its palatal tilt. This brings it into close relation with the palatal side of the lateral incisor, often displacing its root labially. Clinically, this will be identified by a lingual tilt of the crown of the tooth, sometimes into a crossbite relationship.

Palpation

We have pointed out in the previous chapter that, under conditions of normal development, the tooth is palpable buccally above the deciduous canine for 2 or 3 years prior to its eruption. The buccal aspect of the alveolus should be palpated above the attached gingiva and up to the reflection of the oral mucosa. A wide convex contour of the bone is indicative of the canine, immediately beneath. Care should be taken not to confuse this with the narrower profile of the root of the decidu-

ous canine. In the event that this contour is concave, the palatal side of the alveolar process should be palpated to see if there is a clue to its location there.

The deciduous canine should always be tested for mobility. If this test is even mildly positive, it will suggest that the permanent canine is fairly close to the desired eruption path and that severe displacement is unlikely. In this situation, the unerupted canine may not be palpable on either side of the alveolar ridge.

Radiography

As we shall see later in this chapter, to plan the strategy of mechanotherapy properly for a particular case and to obtain a pretreatment assessment of the periodontal prognosis of the treated result, it is essential to know the exact positions of both the crown and the root apex of the unerupted tooth. A single periapical radiograph is essential to identify pathology, such as root resorption, obstruction and cystic change, but it should be supplemented by other films that will help to locate precisely the unseen tooth.

The use of a second periapical radiograph in the parallax method has the advantage of simplicity of technique, and provides both the orthodontist and the surgeon with important information regarding positioning, although the precise locations of crown and apex are difficult to compute from these pictures. A true lateral view (as seen on the lateral cephalogram or on a tangential film) paired with a vertex occlusal or postero-anterior cephalometric view are technically more difficult to obtain, but will provide the required accurate three-dimensional positional information of the unerupted tooth in its simplest-to-understand form.

A panoramic radiograph, in its central portion, shows the incisor region in the postero-anterior view, and will indicate a palatal displacement as an overlap of the impacted canine with the roots of the incisors. This is by far the most popular method used today. However, the canine/premolar/molar areas

are recorded on the same film in the lateral (sagittal) plane and not in the antero-posterior plane, as the consequence of the rotation of the X-ray beam. Thus the film may be misleading in relation to the canine that is not mesially displaced.

TREATMENT TIMING

From the age of about 9 or 10 years, it is usually possible to palpate a normally developing maxillary permanent canine tooth on the buccal side of the alveolus, high above its deciduous predecessor. The greater the degree of crowding, particularly after the eruption of the first premolar, the more buccal is the displacement and the more palpable will the canine become, as its eruptive process brings it further and further down on that side of the arch.

In the event that the tooth is not palpable at this age, radiographs should be taken to assist in locating the tooth accurately and to secure other information regarding the presence, size, shape, position and state of development of individual unerupted teeth and any pathology. In a patient younger than 9 years, the radiographs will not usually show abnormality in the position of the unerupted canine teeth, even if the canines are not palpable and even if they are destined subsequently to become palatally displaced.

Many of these non-palpable canines will finally erupt into good positions in the dental arch, in their due time, provided that there is little or no mesial and palatal displacement of the crown of the unerupted tooth. It may be argued that even canines with an initial mild palatal displacement will achieve spontaneous eruption and alignment despite a first stage displacement, if they undergo secondary correction (see 'Guidance theory of impaction' in the section on Aetiology). Other canines, however, will not erupt, and their positions may worsen in time, as may be seen in follow-up radiographs. If it were possible to distinguish between the two early enough, a line of preventive treatment might be advised.

Preventive treatment and its timing

Using panoramic radiographs of young patients in the mixed dentition, Lindauer et al (1992) were able, to a low degree of reliability (78%) only, to predict palatal impaction on the basis of canine overlap of the root of the lateral incisor.

Extraction as a means of prevention: deciduous canines

As we indicated earlier in this chapter, several authorities (Ericson and Kurol, 1988c) prescribe the extraction of the deciduous canine teeth in an attempt to encourage the permanent canines to erupt. They have recommended seeing the patient and diagnosing the palatal positioning before the age of 11 years, and have shown that extraction performed at this time offers a good prognosis for the natural eruption of the canine, with 78% of the canines in their sample erupting into a clinically correct position. Caution must be advised in interpreting these results, however, since the authors did not study an untreated control group, and thus are not in a position to determine just how many of these teeth would have erupted without this preventive treatment (Lindauer et al, 1992) (Figs 6.13 and 6.14).

From their study, Ericson and Kurol concluded that prognosis becomes less favourable as the palatally displaced canine's medial overlap of the lateral incisor root increases and as the angle between the long axis of the canine and the mid-sagittal plane widens. They also noted that, if positional improvement of the canine was not evident within 12 months of the extraction, it was unlikely that improvement would occur.

From this discussion and from some considerable anecdotal clinical experience, we may assume that, under certain circumstances, the extraction of a maxillary deciduous canine may be a useful measure in the prevention of insidious canine impaction. To achieve maximum reliability, the following conditions should be met before extraction is advised.

- 1 The diagnosis of palatal displacement must be made as early as possible.
- 2 The patient must be in the 10–13-year age range, preferably with a delayed dental age.
- 3 Accurate identification of the position of the apex should be made and confirmed to be in the line of the arch.
- 4 Medial overlap of the unerupted canine cusp tip should be less than half-way across the root of the lateral incisor, on the panoramic view.
- 5 The angulation of the long axis should be less than 55° to the mid-sagittal plane.

The latter two items on this list represent conditions that, if not fulfilled, may still lead to spontaneous eruption and alignment, so that, while the chances are reduced, extraction may still be worth considering.

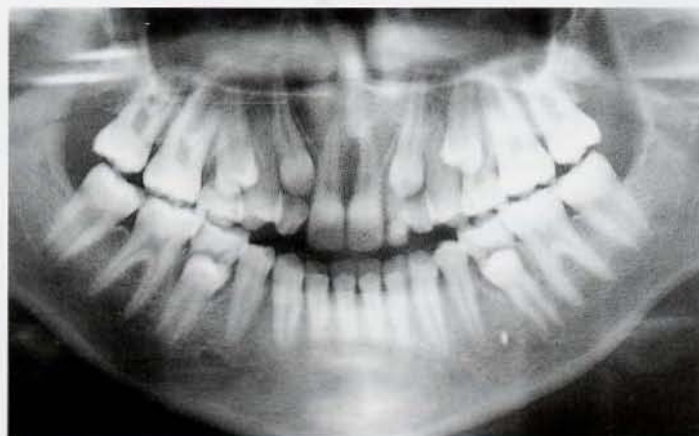
Given that there is no truly reliable method of early detection of a potential palatal displacement (Lindauer et al, 1992), the claim that pre-emptive extraction of the deciduous canine has elicited the normal eruption of the permanent canine must be viewed with some reservation, on the basis of the present state of our knowledge. Clinical experience would lead us to be encouraged by the procedure in many cases, but an accurate assessment of its efficacy has still to be determined.

Extraction as a means of prevention: first premolars

Within the minority group of patients with impacted canines who are considered to be extraction cases, usually because of incisor crowding, a Class II relation or bimaxillary protrusion, the choice of teeth for extraction usually devolves upon the first or second premolar teeth. The reasons for this particular choice are bound up with the history of orthodontics itself. This offers much potential benefit to the displaced canine, since the proximity of these teeth to the canine facilitates the immediate provision of space close by. It also affords considerable opportunity for a spontaneous improvement in the canine position (Fig. 6.15), during the early levelling and aligning stages of the mechanotherapy.



(a)



(b)

Figure 6.13

(a) A case diagnosed from this panoramic view as having bilateral palatal canine displacement and referred for extraction of the deciduous canines. (b) A year later, a repeat film shows great improvement in the position of both canines, and normal eruption of the canines is imminent, despite the fact that the deciduous canines had not been extracted.

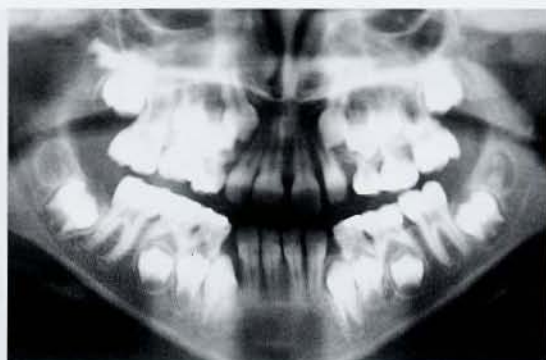
Extraction as a means of prevention: lateral incisors

We have noted above that many of the impacted cases that we see are associated with anomalous lateral incisors. At the end of the treatment procedure, it is often necessary to alter the shape of these teeth by prosthetic

crowning, laminates or composite build-ups, in order to make them aesthetically acceptable, particularly those that are peg-shaped. We have pointed out earlier that palatal canine cases generally have spaced dentitions, comprising small teeth, such that crowding and the need for extractions in the overall treatment is unusual. Nevertheless, if



(a)



(b)



(c)

Figure 6.14

(a) A case of early crowding treated by extraction of four deciduous canines, to relieve crowding at age 8 years. No hint of impending palatal displacement of the canine is discernible on this panoramic film. (b) One year later, the incisors are aligned and spaced. Extraction of the four deciduous first molars (the second stage of serial extraction) was advised. (c) The panoramic view taken a year later reveals the maxillary right canine in a palatally displaced location, despite early extraction of the deciduous canine. Treatment of this case may be seen in Fig. 6.35.

extraction has to be made to treat the overall malocclusion in these cases, consideration should be given to the extraction of these malformed lateral incisors, as an alternative to the conventional but healthy and anatomically perfect first premolars.

We have described how the guidance theory of eruption of the canine offers a cogent argument of how palatal displacement of the canine may occur. In those cases described as a first-stage displacement, it was pointed out how the vertical wall of the alveolar process on the palatal side steers the vertically and palatally directed eruption on a more buccal course, to produce a secondary

correction. This continues until the developing canine comes up against the root of a late-developing lateral incisor, which forms a barrier to its further progress. A second stage impaction is thus created.

Logically, the removal of this barrier should lead to a natural improvement in the position and eruption status of the impacted canine – the second-stage impaction with secondary correction. In practice, clinical experience shows this to be largely true (Fig. 6.16).

Extraction of the lateral incisor is not a suitable procedure in most cases, but in those patients where it is indicated, treatment time may often be very short. However, a nor-

mally sized canine adjacent to a central incisor may create a marred and unsatisfactory appearance, particularly if the central incisor has a poor profile (frequently seen in these cases). Furthermore, by lining up the canine and first premolar in place of the lateral incisor and canine, a discrepancy between upper and lower tooth sizes may compromise the occlusion.

Orthodontic space opening

The preventive measures that we have described up to this point have involved the extraction of teeth adjacent to the impacted only, namely the deciduous canine, the lateral incisor or the first premolar, in the hope that the impaction will resolve spontaneously. An alternative and sometimes supplementary line of preventive treatment involves the generous opening of space for the teeth, using orthodontic appliances. One of the primary

functions of orthodontic treatment preparatory to the treatment of impacted teeth, is the creation of space in the dental arches for the impacted teeth. When this is done, unerupted teeth may often steadily improve their positions, as will be seen on repeat radiographs, and may often erupt without surgical intervention (Fig. 6.17). This is clearly due to an alteration in the relation of the canine crown to the roots of the incisors and a concomitant alteration in the guidance influence of these teeth. It provides further evidence to support the guidance theory of impaction.

Timing of mechanotherapy

Most cases are not identified early enough to take advantage of these preventive steps, and will usually be seen for the first time by the orthodontist only after the initial and, by



(a)



(b)

Figure 6.15

(a) The left side of a Class II division 1 case with bilateral maxillary palatal canine impaction. The maxillary deciduous canines, deciduous second molars and first premolars were extracted and an attachment placed on each of the impacted canines. No active orthodontic treatment was commenced. (b) The same side seen 14 weeks later. Both canines and second premolars have erupted spontaneously and to a similar degree. Appliance therapy was initiated at this point.



(a)



(b)



(c)



(d)



(e)

Figure 6.16

(a,b) A palatally impacted right canine is adjacent to the peg-shaped right lateral incisor, while the opposite canine has erupted in place of the congenitally absent lateral incisor. (c,d) The periapical films used to diagnose the palatal position of the canine by parallax. At the time of extraction, the palatal position of the canine was confirmed clinically. (e) The canine has erupted on the buccal side.



Figure 6.17

(a-c) A Class II, division 2 case with crowding in the maxillary arch and severe space loss due to early extraction in the mandibular arch. (d) A panoramic view shows a palatally displaced right maxillary canine. (e) A similar radiograph taken following distal movement of all four molars and space reopening. Note improved positions and prospects of all the unerupted teeth, particularly the canine. (f-i) The final dental alignment and occlusion.

then, more obvious diagnosis has been made by the generalist or paedodontist. A coexisting malocclusion has often been the reason for the patient requesting treatment, and the impacted tooth will have been discovered only as the result of the orthodontist's routine clinical and radiographic examination.

The patient is generally in the full permanent dentition stage, with the exception of the deciduous canine of the affected side. Sometimes, the remainder of the dentition is in a close-to-ideal alignment and inter-arch relation, as has been pointed out earlier, although a minor degree of local tooth malalignment may often be seen. This generally includes a laterally flattened or collapsed arch form (Fig. 6.18) and space loss in the immediate area, with space opening more mesially (Oliver et al, 1989). In only about 15% of the cases (Jacoby, 1983; Becker, 1984) is actual crowding present.

The periapical radiographs should be carefully scrutinized to discover any evidence of resorption of the lateral incisor roots. Should this be seen, orthodontic treatment, designed to rapidly deflect the developing canine away from the incisor, should be undertaken as

soon as possible. If the resorption is advanced, consideration should be given to extraction of the lateral incisor, in the relatively unlikely event that the case is an extraction case.

For the most part, however, there is rarely any reason to hurry into treatment simply because palatal displacement has been diagnosed. The patient must first be prepared for the treatment that is to be undertaken, initially by explaining the nature and ramifications of the problem, using the radiographs and plaster models as visual aids. The principal function of this exercise is to overcome a complacency that most of these patients have, since their problem is one in which the facial appearance and oral function are rarely compromised. The aim is to inspire motivation and the necessary future cooperation.

The dentition must then be protected against the incipient dangers that the placement of appliances is likely to generate. The necessary measures include a high level of oral hygiene and the use of appropriate fluoridating procedures, both at home and in the dental office, as well as the treatment of any carious or periodontal lesions.

After a period of a few weeks, during which the patient will, it is to be hoped, have undertaken these oral hygiene responsibilities on a regular basis, an oral examination should show pink, firm and stippled gums and an absence of plaque on the teeth. This being so, the time will be ripe to begin orthodontic treatment. In the non-cooperative patient, treatment should be denied until the above conditions are fulfilled. Should the dental awareness of the patient be too low for this ever to occur, alternative treatment modalities should be considered, particularly prosthetic replacement, although, for these to be successful in the long term they may be just as reliant on oral hygiene as is orthodontic treatment. Nevertheless, an operative decision may be delayed for quite a long time, in view of the relatively low incidence of morbidity, provided that periodic radiographic monitoring is performed.

Postponement for a few months or even a year is rarely a problem in straightforward orthodontic terms, and if it serves to bring the



Figure 6.18

A preformed archwire blank laid over the occlusal surfaces of the teeth closely conforms to the dental arch, except in the area of the impacted canine, which shows lateral flattening.

patient round to the ways of proper home care then the time spent will have been worthwhile. Unfortunately, as already mentioned, the dental development is often delayed, which is why these patients reach the permanent dentition stage with the canine impaction diagnosis made only at the age of 14 or 15 years. Thus, from a social point of view, the patient may be less inclined to wear appliances if further postponement is entailed.

From the strictly developmental point of view, the best time for therapeutic intervention is when the root of any affected tooth is of a length that is seen at the time of normal eruption. For the canine, this is a little in excess of three-quarters of the potential root length, which is virtually always present by the time the diagnosis of palatal displacement may be determined.

GENERAL PRINCIPLES OF MECHANOTHERAPY

When a patient arrives at the orthodontist's office and a palatally displaced and unerupted canine is diagnosed, treatment must be planned in a disciplined manner. We have seen in Chapter 5, in regard to the impacted maxillary central incisor, that orthodontic preparation of the case is required and that surgical intervention is not to be undertaken in any haphazard or unplanned manner. Appliances that are to be used to disimpact, erupt and align these teeth may also be used to align the other teeth, with very little modification. For this reason, the local anomaly and the overall malocclusion are usually dealt with together in one full and comprehensive orthodontic treatment plan.

A diagnosis of the overall malocclusion needs to be made and a problem list set out, which includes the palatal canine. The problem list is then rearranged into a treatment priority list, in which alignment of the impacted canine should precede many of the other items to be treated. The same principles that were used in the planning of treatment in Chapter 5 are equally applicable in the pre-

sent context, although we shall now be dealing with the treatment of the entire dentition and not merely the area immediately adjacent to the impacted tooth.

The principles, as they relate to the palatally displaced canine case, need to be adapted to the new circumstances, and may therefore be presented as follows.

- 1 The appliance should have the capability to *level and rotate* all the teeth in the same jaw rapidly, and, with controlled crown and root movements, to *open adequate space* to accommodate the impacted tooth. As we saw when dealing with impacted incisors, this space is required both at the occlusal level and between the roots of the adjacent teeth for their entire length. This stage requires the use of fine leveling and aligning archwires.
- 2 With the initial alignment achieved and no further movement of individual erupted teeth needed, these teeth are transformed into a composite and *rigid anchorage unit*, in which each of the teeth plays an integral part. This is done by substituting the flexible archwires with a heavier wire, whose gauge is as large as the bracket will take, in order to allow as little 'play' of wire within the bracket as possible, thereby maximizing the anchorage value of each tooth.
- 3 The *surgical exposure* of the crown of the impacted tooth should be performed in a manner that will achieve a good periodontal prognosis of the treated result. An attachment is bonded to it and the flap fully closed, with only a fine ligature wire leading through the gingival tissue to the re-covered tooth.
- 4 Using an auxiliary means of traction from the now rigid orthodontic appliance, a gentle and continuous light force, with a wide range of activity, is applied to the tooth, and is aimed at *erupting the impacted tooth* along a path that is free of obstruction from neighbouring teeth (Becker and Zilberman, 1975, 1978; Jacoby, 1979; Kornhauser et al, 1996).
- 5 There should be *final detailing* of the position of the formerly impacted tooth,

together with that of all the other teeth in both jaws. A *Class II* or *Class III dental relation* will usually be reduced at this point. However, it may sometimes be treated earlier in the first of these stages and before surgery is contemplated, for example when early orthopaedic treatment is to be undertaken with the use of a functional or en-bloc headgear appliance, in the mixed dentition stage.

There are essentially four ways in which space may be provided for the palatally displaced canine.

1 *Existing incisor spacing may be closed off by moving the lateral incisor mesially.* Incisor spacing is due to the failure of completion of the ugly duckling stage of development (Broadbent, 1941; Becker, 1978). It was pointed out at the beginning of this chapter that the final stage in anterior space closure occurs when the canine erupts and influences the lateral

incisor to move mesially. It was also pointed out that these impacted teeth are intimately linked with small and peg-shaped lateral incisors and with small teeth in general. This being so, it is common to find anterior spacing in these patients (Fig. 6.19).

2 *Improving archform.* When the maxillary permanent canine erupts normally, it does so along a more buccal path than the deciduous canine and slightly buccal to the lateral incisor and first premolar, earning the tooth the title of 'cornerstone of the arch'. Comparing the two sides of the maxillary arch in a unilaterally affected patient, we have already pointed out that, in the canine areas, there is a much narrower maxillary width on the side of the deciduous canine than on the normal side. Exploiting the improvement in this archform, produced by an orthodontic appliance, will add two or three millimetres of space for the displaced tooth (Fig. 6.20).

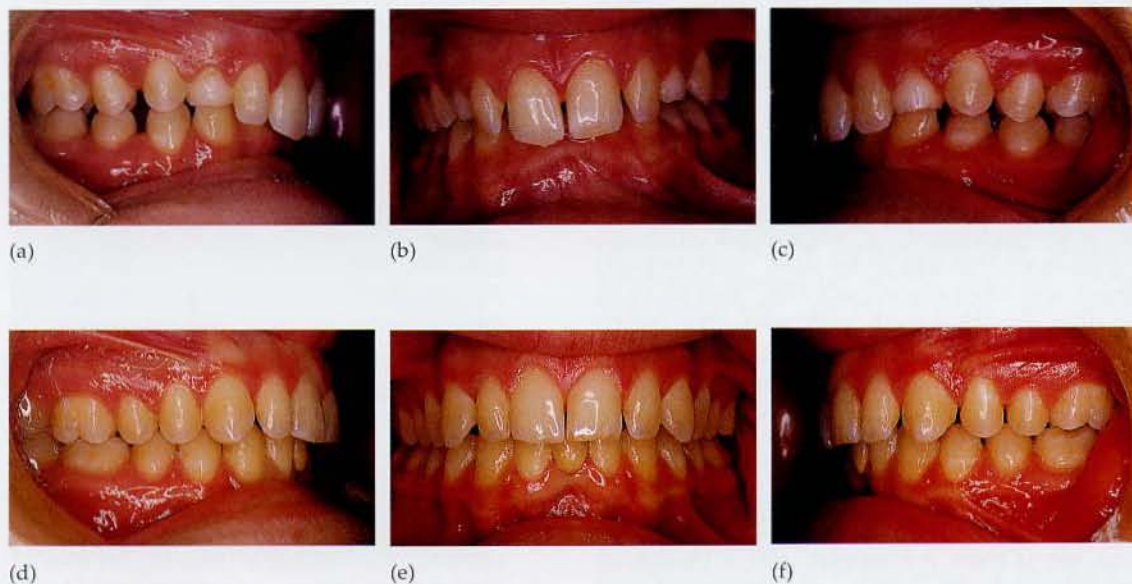


Figure 6.19

(a-c) Inadequate space for unerupted permanent canines with interincisal spacing. (d-f) The permanent canines in place at the completion of treatment.



(a)



(b)

Figure 6.20

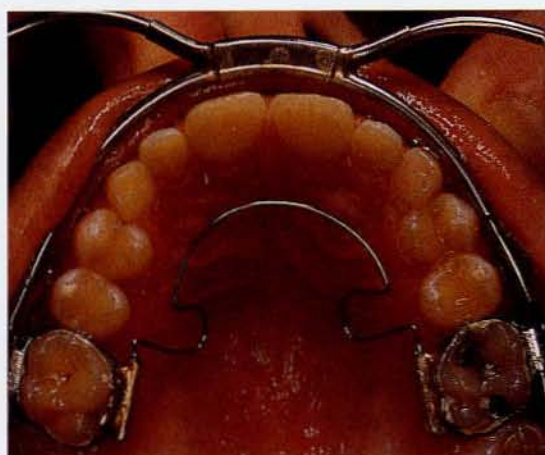
(a, b) Improving the archform has provided adequate space.

- 3 *Increasing arch length.* If crowding is mild, the use of a headgear is recommended in order to move the maxillary molars distally. This will provide the extra space further forward, which may then be concentrated in the canine area, using a multibracketed appliance system (Fig. 6.21). Treatment is begun with fine levelling archwires, until the individual tooth heights, bucco-lingual positional discrepancies and rotations have been corrected, and uprighting has been achieved as necessary.
- 4 *Extraction of teeth.* When crowding is more severe, particularly where there is also a Class II dental relation that is to be treated with the use of intermaxillary elastics, the extraction of a premolar tooth on each side of the dental arch in the maxilla and, usually, in the mandible will be required. With the extraction of the premolar, space for the impacted canine is immediately and very locally available, and so appliance therapy is not needed to provide the space. Secondly, following the loss of the first premolars, alignment, levelling and rotation of the remaining teeth are very much simplified. Thirdly, with a local anaesthetic already covering

the area and a surgical wound inevitable, it is logical to extract the deciduous canine and expose the impacted canine at the same time, to reduce the number of surgical interventions and post-surgical discomfort to a minimum. Thus, in extraction cases, it may be recommended that the surgical exposure be undertaken prior to the placement of an appliance (see Fig. 6.15).

The achievement of good archform is an important initial goal in the maxillary arch in non-extraction cases. After the initial levelling wires, a coil spring is placed on a more substantial archwire of idealized form, to increase the canine space by moving the lateral incisor mesially and the first premolar distally, until interproximal contacts are established elsewhere in the maxillary arch. This will usually provide more than enough space for the unerupted canine.

A heavier-gauge archwire is now firmly ligated into the maxillary appliance, and the space for the canine must be retained. In the various edgewise and prescription pretorqued bracket techniques, as heavy a rectangular base arch as possible should be used. In the Begg and Tip-Edge techniques, a round



(a)



(b)

Figure 6.21

(a) An extra-oral headgear is being used to move the molars distally. The tied-in light palatal arch will be removed and used later for vertical traction when the canines are exposed. (b) After the premolars have been moved distally, more-than-adequate space has been prepared for the unerupted canines, seen here at the time of their exposure.

0.020" or 0.022" wire respectively should be used as the base arch, with the addition of uprighting springs or torquing auxiliaries to act as 'brakes', if necessary.

The space that has been reopened for the canine may be maintained using the same coil spring, which will need to be deactivated. However, it is difficult to adjust the spring to maintain a space accurately, and one will usually find that the space will increase or decrease slightly over the succeeding months. Furthermore, a coil spring quickly fills with food particles and is impossible to clean effectively. A much better alternative involves using a measured and slightly curved length of stainless steel tubing, which is threaded on the archwire and is tied or pinned between the brackets of the premolar and lateral incisor, in place of the coil spring. This adds a great deal of rigidity to the archwire in the area of greatest importance, and helps in resisting distortion, thereby providing an excellent and firm base from which to apply force to the impacted canine. Many of these canines have to be moved over a long dis-

tance to bring them into the arch, and several will require root movement of the different types before they may be properly brought into position and the case completed. This inevitably expends anchorage. The measures and precautions that we have described will contribute much to preserving the anchorage.

THE NEED FOR CLASSIFICATION OF THE PALATAL CANINE

During the orthodontic treatment of a patient, as with any other prescribed form of medical or dental treatment, attention is paid to achieving the maximum benefit that the approach has to offer, while sustaining the minimum possible adverse changes in the health of the dentition and its supporting tissues that may be caused by the treatment. To this end, the orthodontist must ensure an adequate level of oral hygiene before and during the period when the procedures are performed. The forces generated by the appli-

ances must be within certain limits, compatible with physiological tooth movement, so that permanent and irreversible damage is not inflicted on the dentition.

In an extraction case, the decision regarding which teeth to extract is usually made on strictly strategic criteria, insofar as certain teeth require to be brought to particular places, and appropriate anchor teeth need to be chosen in order to achieve this. Given a good prognosis of each of the teeth in the mouth, with no severely carious teeth and excellent periodontal health, the criteria of orthodontic treatment strategy are the guiding criteria behind this extraction decision.

However, when a tooth or teeth are present whose long-term prognosis is in doubt, such as a molar tooth that is in need of root canal treatment and a post-and-crown restoration, this becomes an additional factor that must influence the choice of tooth for extraction. It would not make long-term sense if the immediate and beautiful orthodontic results were to be based on teeth that would not be present in the mouth a few years later, while healthy teeth of excellent prognosis had been sacrificed in the name of strategic convenience.

Maxillary canine impaction in a case where teeth require to be extracted as part of the overall orthodontic treatment presents a similar dilemma. The canine has a longer root and contributes much to the patient's appearance, particularly the smile, which makes it a very valuable tooth and one worth the expenditure of considerable effort to bring it into position. Its substitution by a first premolar is not usually desirable. It is inappropriate to automatically and blindly extract an impacted canine with a good prognosis, in preference to an erupted first premolar, just as it is inappropriate to extract a first molar rather than a first premolar simply because the molar has a small occlusal amalgam filling. But what if the long-term prognosis of the canine is poor, as the consequence of its having been through the processes of surgical exposure and orthodontic alignment, over the period of many months or years that were spent in its meticulous alignment? Perhaps it would have been better to remove that particular canine at the

outset and to have brought the first premolar to its place.

Extraction cases are very much in the minority among patients with palatally impacted canines (Jacoby, 1983; Becker, 1984), and so, for the most part, every effort must be made to bring the canine into the arch and to do this in a manner that will provide it with its best possible periodontal prognosis (Freeman, 1994).

The clinician must carefully assess each individual case, to be in the position in which an accurate appraisal of the several aspects where prognosis of the results of the treatment is at stake, prior to the beginning of treatment. With this information, the optimal decision regarding extraction may then validly be made.

At the time that the patient's records are being studied in order to formulate a suitable treatment plan, it would be helpful if there were a way in which it is possible to assess the long-term prognosis of an impacted canine before treatment is started. It is therefore crucial to seek a key that may be available to help us to decide which canines will be adversely affected in periodontal terms:

- (a) by surgical access to them,
- (b) by the relative difficulty in orthodontically moving them into alignment.

From the surgical aspect, which we have discussed in Chapter 3, minimal exposure and full flap closure (with attendant attachment bonding) is the preferred line of treatment, aimed at primary healing.

Does a tooth that requires a whole range of different types of orthodontic movement pay a periodontic penalty, in the final analysis, in comparison with one that is more simply aligned?

Teeth that are mechanically erupted bring with them a generous amount of alveolar bone. It has been shown in studies in Israel (Becker et al, 1983; Kohavi et al, 1984a,b) that the assisted eruption of buried teeth with the use of orthodontic appliances produces a collar of alveolar bone around the erupted tooth that is greater than that seen on normally erupted adjacent teeth. These studies have shown this to be true only where surgical

exposure was conservative and did not involve the removal of the entire follicular sac. Radical surgery leads to less bone support than is present in a normally erupted tooth, and considerably less than the minimally exposed impacted tooth.

The most likely explanation for this is be found in the procedure that prosthodontists call 'forced eruption' (Ingber, 1974; Stern and Becker, 1980). When one side of a tooth is fractured or destroyed by caries to below the height of the crestal bone, an infra-bony pocket is produced. The treatment that is prescribed to eliminate this is to mechanically erupt the tooth away from the bone margin and to thus orthodontically reverse the relationship between prepared crown shoulder or cavity margin and the interproximal alveolar bone. At the same time, the other sides of the same tooth, whose relationship with the bone was normal to begin with, are extruded together with their adjacent alveolar bone. This generates excessive bone in the latter areas, extending more coronally than is normally seen, which sometimes needs to be reduced by periodontal/periosteal surgery.

It has been shown by Ingber (1974) and by Stern and Becker (1980) that, in contrast with extrusive movement, teeth that undergo root uprighting and torqueing movements end up with a significantly lower crestal bone level than untreated controls, and the histogram in Fig. 6.22 shows the influence of the various combinations of conservative-versus-radical surgical exposure and extrusion/tipping-versus-root movement orthodontic forces on the relative bone support of these teeth. These results are an indication of the periodontal prognosis of the teeth concerned.

One last factor, which is often ignored or simply overlooked, relates to root resorption that may occur in the impacted tooth during the extended period of time that may often be involved in its alignment. In orthodontic treatment, generally, resorption of the root apices of teeth may sometimes be seen. The reasons for this occurrence are not clear, although recent evidence has linked thyroid hormone with the phenomenon (Loberg and Engstrom, 1994; Poumparos et al, 1994). Nevertheless, there is no known key that may be used to

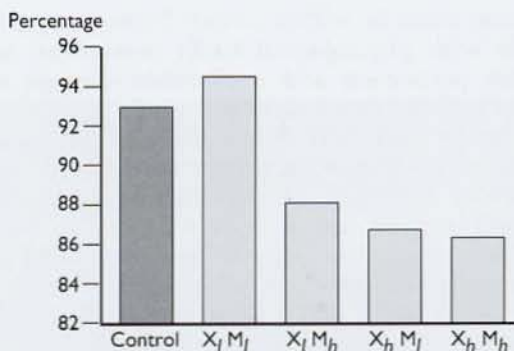


Figure 6.22

Bone support levels in the treated canines (light bars) compared with the normally erupted opposite canines (dark bar): X_I, minimal surgery and primary closure; X_h, surgery in which the follicular sac was removed down to the CEJ; M_I, orthodontic tipping, extrusion and rotation movements only; M_h, root uprighting and torqueing movements. (Adapted from Kohavi et al, 1984b.)

predict in which patients resorption will occur. What is found, however, is that the resorption process almost invariably stops when orthodontic tooth movement is completed.

In most patients for whom major orthodontic movements have been carried out, resorption is exceptionally small and of no clinical significance. Nevertheless, there are occasional cases where these ill effects may account for the loss of 3 or 4 mm of the original root length. It also appears that treatment time has little impact on root resorption, even when treatment has lasted for 6 years (Beck and Harris, 1994)! In the absence of definitive information regarding the mechanisms involved, however, it would seem wise that, for those patients who are prone to root resorption, orthodontic treatment should be kept to a minimum, both in terms of duration and simplicity. The optimal result for that particular patient may not even come close to the ideal.

For the resorption-susceptible case, it could conceivably happen that all the precautions that we have described may be followed scrupulously and a good periodontal result

may be obtained. However, unusually severe resorption may account for a final root length of, say, 12 mm. The same 2 mm difference in height between crestal bone and CEJ will give a relative bone support in this patient of only 83% and the long-term prognosis must be judged accordingly. Thus for cases in which there is a more compromised bone loss in the cervical area, with a greater CEJ-to-crestal-bone height difference, the relative importance of root resorption as a factor in long-term tooth survival increases.

Monitoring for early indications of root resorption may be performed during the progress of the mechanotherapy of a given impacted canine, using periapical radiographs. However, since the position of the tooth is changing during the procedure, comparison with earlier films may be difficult. It should also be remembered that, even when marked resorption is noticed, it is unlikely that the orthodontic treatment will be stopped much before full eruption has been accomplished. Less would render the canine valueless for all practical purposes and under any circumstances.

The efficacy of radiographic monitoring is only relevant at the point when the crown of the tooth has been brought into its place in the arch and a decision has to be made whether root uprighting and torqueing movements are desirable. If a periapical radiograph taken at this juncture shows that significant resorption is evident, its severity must be offset against the relative importance of producing these root movements.

A CLASSIFICATION OF PALATALLY IMPACTED CANINES

We have concluded that

- (a) surgical trauma is greater when access is difficult, and
- (b) orthodontic alignment is more complex when the impacted tooth has a greater displacement, particularly if the root apex is not in the line of the arch.

Yet it is these two factors, both of which relate to the position of the tooth, that will later

dictate the quality of the supporting structures of the treated result. Accordingly, it becomes clear that the patient's best interests are served if an accurate visualization of the exact location of the buried tooth is made at the outset, at the time of treatment planning. It follows that if palatal canines are classified in relation to their position in the maxilla then they will essentially be grouped in accordance with the prognosis of their therapeutic outcome.

The classification that is offered here is based on two variables:

- (a) the transverse relationship of the crown of the tooth to the line of the dental arch, which may be close or distant (nearer the midline);
- (b) the height of the crown of the tooth in relation to the occlusal plane, which may be defined as high or low.

Determination of the location of the crown of the impacted tooth is achieved by employing the radiographic methods that we have outlined earlier. This positional determination may be subsequently confirmed by direct vision at the time of surgical exposure.

In this section, several cases will be presented to illustrate the salient clinical features of the impacted canines in each of the classification groups. An approach to treatment will be discussed within each group, and how this needs to be adapted to suit the conditions seen in each. Where relevant, cases that were treated inappropriately will also be presented, with the aim of revealing how the shortcomings of the results occurred and to discuss what alternatives could have been employed to prevent the undesired sequelae.

Group 1

- Proximity to line of arch: close
- Position in maxilla: low

Typically, palatal canines that are close to the line of the arch and low in the maxilla suggest a good prognosis, insofar as the tooth is usually palpable in the palate and readily accessible to surgery (Fig. 6.23). In its simplest form, the

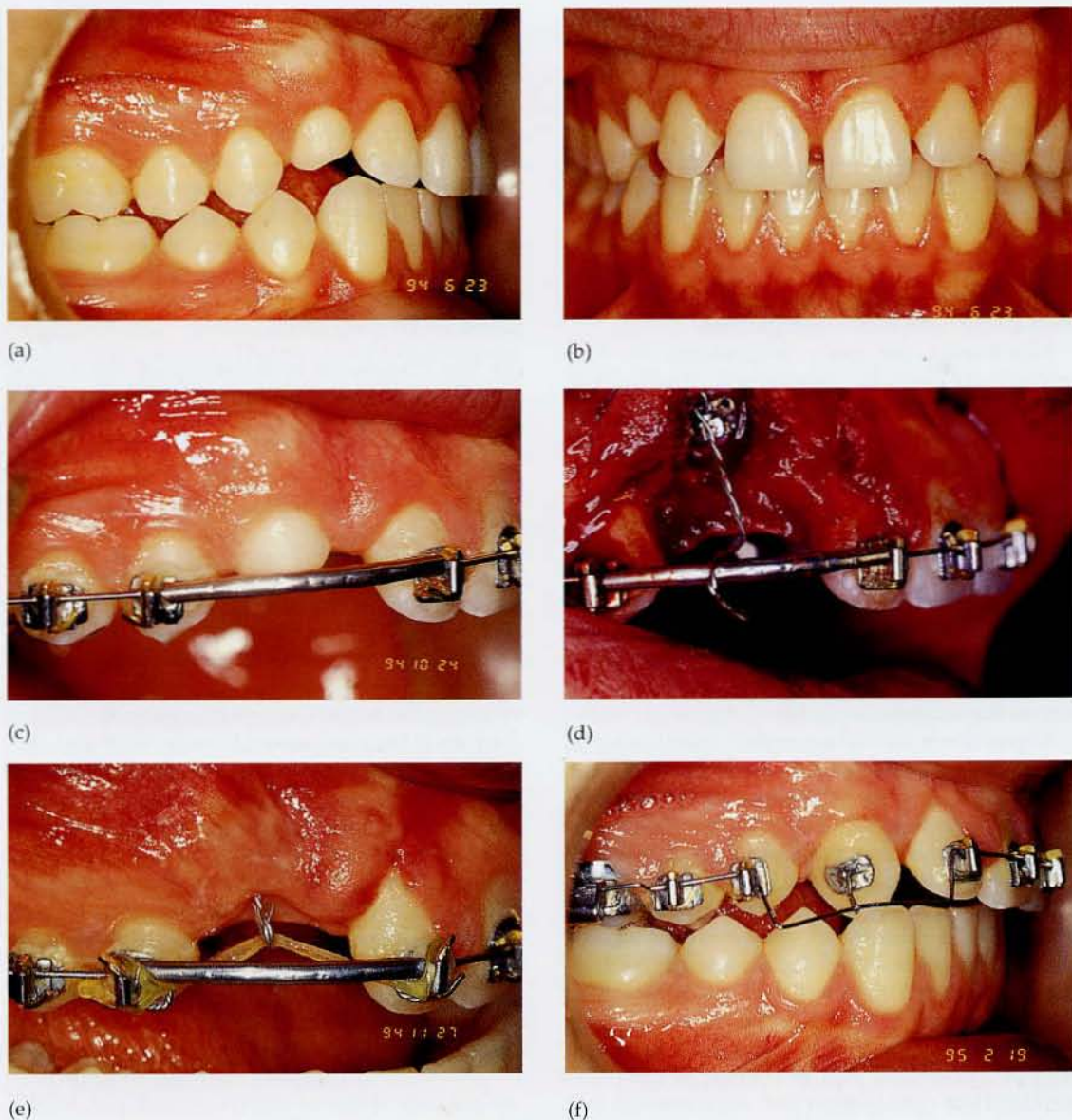


Figure 6.23

(a,b) Intra-oral views of the initial condition. (c) Space was opened using a coil spring and sliding mechanics. An oversized stainless steel tube is cut to measure, curved and placed on the archwire to maintain space and to increase base arch rigidity. (d) Exposure and attachment bonding. The pigtail ligature is drawn downward and L-shaped over the archwire to allow for reapproximation of flap without impingement. Traction was applied immediately. (e) Two weeks post-surgery, a new 'slingshot' elastic module is stretched between the brackets of the lateral incisor and first premolar. Its middle portion is raised to engage the pigtail hook with a controlled and measurable light extrusive force. (f,g) Three months post-surgery. An inferiorly and laterally offset light wire arch is substituted, and the tooth ligated with steel ligature wire to achieve full eruption. An orthodontic bracket now replaces the eyelet. (h,i) The gingival appearance shows comparable gingival levels on the treated versus the untreated side. (j,k) Periapical view, showing comparable supporting bone levels in the treated and untreated canines.

(Figure 6.23 continued)



(g)



(h)



(i)



(j)



(k)

canine is opposite the space and is not rotated. The root apex is usually in its correct location and root movements are rarely necessary.

Surgery

Approached from the occluso-buccal (Fig. 6.23d), little bone removal is needed to reach the canine. Alternatively, following the reflection of a palatal flap, the canine is immediately obvious under its bulging but thin covering of bone, on the inner surface of the alveolar ridge. Minimal removal of eggshell-thin bone is needed to reach the follicular sac,

and access for bonding an attachment to the tooth is good. After resuturing of the full flap, the pigtail ligature is drawn through the sutured edge in the direction of the main archwire.

Planning the orthodontic strategy

With the tooth immediately opposite its place in the arch, orthodontic alignment requires some extrusion, but principally a buccal tipping movement. Thus direct force application between pigtail and archwire is the most appropriate (Fig. 6.23e).

Problems that may be encountered

In the simplest group 1 case, the eyelet may often be sufficient to complete all the movements required. Alternatively, and if surgery has exposed a sufficiently long clinical crown, a conventional bracket may be placed immediately. However, it should be remembered that, as the tooth moves buccally, it gathers gingival tissue ahead of it, and, if oral hygiene is not excellent, the exuberant soft tissue will become inflamed and may impinge on the bracket. Undoubtedly, wider exposure of the crown will eliminate this, but will compromise the periodontal tissues in the final analysis. Thus it is wiser to use an eyelet initially.

Complications

Group 1 canines, in their initial positions, may be complicated by rotation, mesial crown displacement or palatal root displacement.

(a) *Rotation.* The type of rotation that the canine generally presents is a mesio-lingual rotation, with the buccal surface of the tooth facing mesially, towards the root of the lateral incisor. This means that, during treatment, the appliance must incorporate a rotational mechanism to bring the tooth into alignment. The simplest manner in which to do this is to initially place the eyelet on the anatomic labial surface of the crown of the canine, which faces anteriorly, towards the lateral incisor.

The 'slingshot' elastic is placed or elastic thread tied between the eyelet and the cut length of stainless steel tube (Fig. 6.23c) that has been threaded on to the main archwire, for use as the canine space maintainer and to add rigidity to the base arch. While the canine is being moved towards the line of the arch, it is also being rotated about its long axis, in a corrective mesio-buccal rotatory movement. Since the stainless steel tube space maintainer will not allow individual movement of the adjacent teeth, the direction of rotation may be changed or increased to fit other types of rotated palatal canines, by tying the elastic

thread from the eyelet directly to the premolar or lateral incisor teeth.

(b) *Mesial crown displacement.* This is very commonly seen in conjunction with the mesio-lingual rotation that we have just described. Whether or not the rotation is present, the proximity of the anatomic labial surface of the canine to the lateral incisor creates constraints on the placing of a bracket at the midbuccal position of the canine crown. As a general rule, this space is too small for the placement of any of the conventional brackets, which are so much bulkier. To overcome this drawback, many practitioners bond the conventional bracket, with its rigid and contoured base, on the irregular palatal surface of the tooth, to which it is totally unsuited.

A further drawback is that traction applied directly between the bracket and the archwire will substantially increase the rotation of the tooth. This will be very difficult to correct later, and will significantly increase the amount of mechanotherapeutic manipulation that the tooth must undergo and the periodontal prognosis of the tooth will be compromised unnecessarily.

Traction from an eyelet placed in the ideal midbuccal position on the tooth, even if it is more incisally placed because of the physical limitations imposed by the proximity of the lateral incisor, will bring about a corrective rotational movement as the tooth is drawn towards the target area. Palatal bracket-siting risks a complication (the detachment of the bracket), and while it solves one problem (the impaction), it creates another (increased rotation).

It is relatively easy to bond an eyelet close to the ideal midbuccal position of the exposed tooth and to draw elastic thread from it to the rigid tubing that has been placed on the archwire to maintain the canine space in the arch. It may be advantageous to tie the elastic thread to the bracket of the first premolar, to increase the mesio-buccal rotatory component of the traction. The premolar will not close down the canine space, because of the presence of the stainless steel tubing. An extended period of traction will, however, slowly bring about adverse changes in the dental midline,

by tipping of the incisors in the light-wire techniques, unless mesial uprighting springs are placed as 'brakes' on the incisors to increase their anchorage value.

(c) *Palatal root displacement.* If the root apex of the canine is palatally displaced, in addition to the palatal crown displacement, the crown will first need to be aligned in the manner that we have just described. This includes the correction of any possible rotation and mesial crown displacement. With the canine crown in place and the main archwire firmly ligated into the newly substituted, conventional bracket, the palatally inclined long axis of the tooth will dictate that its palatal surface bulges inferiorly, while the buccal surface tips superiorly.

The heavy archwire is now needed to serve as the base arch to a labial root-torqueing auxiliary. Employing a full rectangular arch, which is torqued in stages on the canine only, the long-axis inclination will be seen to improve in time. At the same time, the roots of the adjacent teeth, which provide the anchorage for this difficult movement, are themselves being torqued lingually, at each torque-adjusting stage and then buccally as the torqueing force is expended. Regardless of the type of orthodontic brackets employed, there are advantages to using a torqueing auxiliary that derives its anchorage from the narrowed archform of the main archwire. This will avoid distortion of the dental arch, and will not create unwanted 'round-tripping' movements of the adjacent teeth.

Group 2

- Proximity to line of arch: close
- Position in maxilla: forward, low and mesial to lateral incisor root

The root apex of the canine in this group is usually to be found in its correct place, in the line of the arch and at more or less the correct height. The crown of the tooth, however, is tilted mesially (forward) and in close associa-

tion with the palatal aspect of the root of the lateral incisor (Fig. 6.24) and often sited between the roots of lateral and central incisors (Becker and Zilberman, 1978). The tooth is not always palpable on the palatal side.

Surgery

Surgical exposure in this group is complicated by the often unavoidable simultaneous exposure of the roots of these adjacent teeth. Aggressive surgical techniques may occasionally open the way for the orthodontist to bond on the labial surface, but not without considerable damage to the adjacent exposed incisor roots by the radical removal of bone.

With the position of the crown of the impacted canine situated mesially to the root of the lateral incisor, several operative problems present themselves. In the first place, surgical exposure has to be carefully undertaken, so as not to damage the roots of the incisors. The temptation to expose too widely should be resisted, and only enough of the



Figure 6.24

The periapical view of an extreme example of group 2 canines. The left canine is located between lateral and central incisor roots, and the right canine is mesial to the central incisor root.

most conveniently accessible surface of the tooth should be uncovered, to permit bonding. The palatal surgical flap should be replaced in its entirety, in order to provide maximum protection for the exposed incisor roots and the area of exposed bone, and to re-establish a normal periodontium. However, to provide an exit for the twisted ligature pigtail that is tied to the attachment, the flap is divided into two halves by a slit that is made with an electrocautery, rather than a scalpel, in order to prevent bleeding at the cut edge. The pigtail is passed through the slit, and the two-part flap is sutured back into place. Alternatively, the pigtail ligature must be carefully passed through a small hole (Fig. 6.25) punctured into the flap, which is not easy to perform under these circumstances.

The mesio-palatal rotation of the canine that is usually present in these cases places the labial surface of the canine in a completely inaccessible position. This means that only the palatal aspect of the canine is available for siting the attachment.

Planning the orthodontic strategy

From an eyelet placed on the palatal side of the tooth, direct traction to the labial archwire is sometimes possible. However, if traction is



Figure 6.25

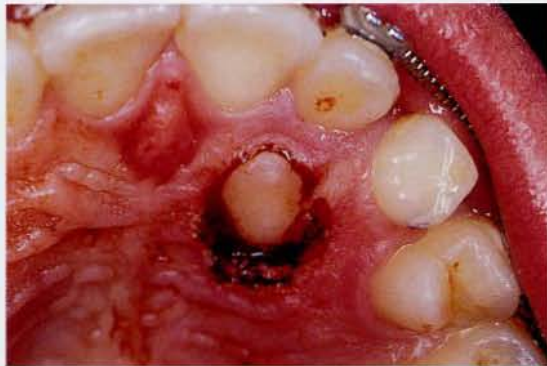
The flap is fully sutured back to its place, and the steel pigtail may be seen to emerge through a needle-pierced hole in the flap.

performed in this manner, the attached surface leads the way, and it will inevitably cause the canine to 'roll' over the root of the lateral incisor, to increase the existing rotation (Fig. 6.26). Once the tooth reaches the archwire, the operator could be faced with a 180° rotation to perform! Few will dispute that this task is very formidable, but, before the adventurous clinician even begins to argue that it is not an impossible stumbling block, the following three questions should be considered. How long will the de-rotation prolong the appliance therapy? Will the rotational relapse factor be possible to overcome? What will be the prediction for the health of the periodontium at the completion of correction of the iatrogenic rotation?

For many of the impacted teeth in group 2, the intimate relation between canine crown and lateral incisor root will block movement of the canine when direct traction is applied. The inexperienced operator may then respond by increasing the pressure applied to the tooth, and, within a fairly short period of time, there will be signs of loss of anchorage on the other teeth, characterized by the production of a crossbite tendency and a midline shift from the affected side, not to mention the possibility of damage to the lateral incisor root.

A completely different approach must be used, in which the tooth must first be moved in a different direction to free it from its entanglement with the incisor roots. The most practical manner of doing this is to draw it vertically downwards (towards the tongue), erupting it into the palate, in an exercise aimed at converting the impaction into a group 1 case. It may then be moved directly across the line of the arch, towards the labial archwire, in a second movement.

Three types of spring auxiliary may be used to bring about the desired movement that is needed initially, in this first stage of the resolution. These are the ballista (Jacoby, 1979), the active palatal arch (Becker and Zilberman, 1975, 1978) and the light auxiliary labial arch (Kornhauser et al, 1996). In each of these methods, it is essential that a heavy base arch be tied into the brackets of all the teeth on the labial side, the aim being to hold the



(a)



(b)



(c)

Figure 6.26

(a) A group 3 canine has been exposed, and healing is by secondary intention (!). (b) An edgewise bracket (!) has been sited on the palatal aspect of the canine. The tooth is being drawn from its palatal attachment directly to a flexible labial archwire (!). (c) The tooth has reached the archwire, and is now rotated a further 30–40°. Note the swollen appearance of the gingivae and its poor contour.

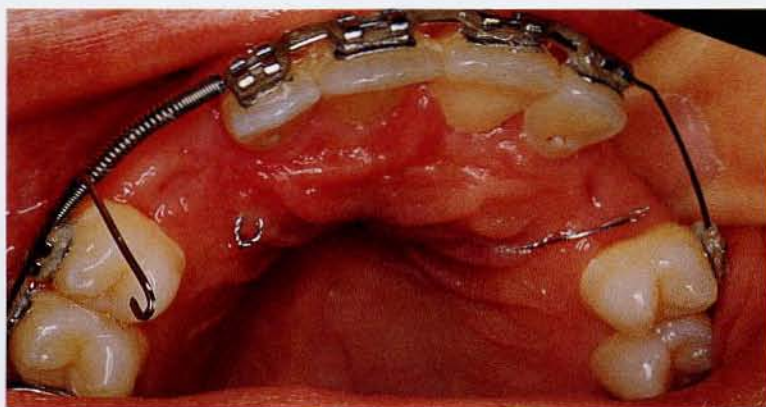
opened space for the canine in the arch, to resist secondary distortion of the occlusal plane and archform, and to provide a base from which to apply the force to the tooth.

The *ballista* (Figs 6.27a,b) is a unilateral spring of rectangular wire, which is tied into one of the rectangular molar tubes. It proceeds forwards until it is opposite the canine space. At this point, it is bent vertically downwards and terminates in a small loop. With light finger pressure, the vertical portion is turned upwards, across the canine space, and tied into the pigtail ligature to lie close to the palatal mucosa. In this way, torque is introduced into the horizontal part of the ballista, which is resisted to a great extent by the molar.

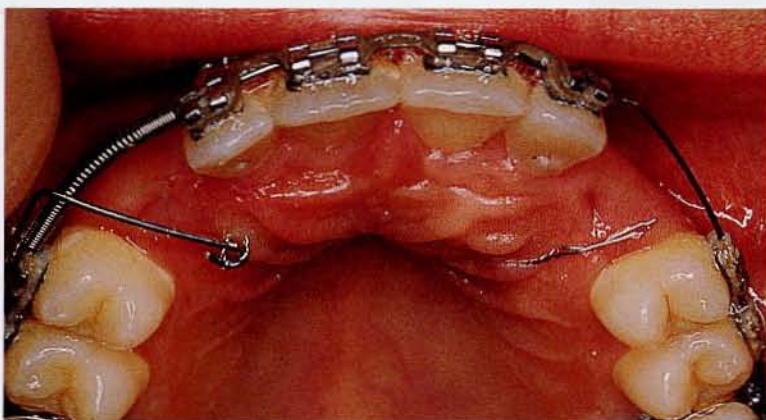
The elasticity of the ballista spring exerts pressure for it to return to its original vertical position, which, in turn, applies extrusive

force to the unerupted tooth. If the impacted tooth is fairly resistant to movement or if the distance that the tooth needs to be moved is great, lingual molar root torque may occur, representing a loss of anchorage. To overcome this, a rectangular main arch or a soldered palatal arch may be used.

The *active palatal arch* (Fig. 6.28a) consists of a fine 0.020" removable palatal archwire, carrying an omega loop on each side. The wire is doubled over at its extremity, to allow it to friction-fit into a soldered horizontal 0.040" tube on the palatal side of the maxillary molars. It is further secured by a steel ligature tie and distanced from the palate by gentle finger pressure. By elevating the downward-activated palatal archwire (Fig. 6.28b) and hooking the pigtail ligature around it, the unerupted tooth comes to be erupted through the palatal tissue, in a direction slightly away from the teeth.



(a)



(b)

Figure 6.27

(a) The ballista in its passive mode, pointing downwards. (b) Using light finger pressure, the looped end of the spring is turned inwards and upwards towards the palate, where it is latched into the stainless steel pigtail from the unerupted canine.

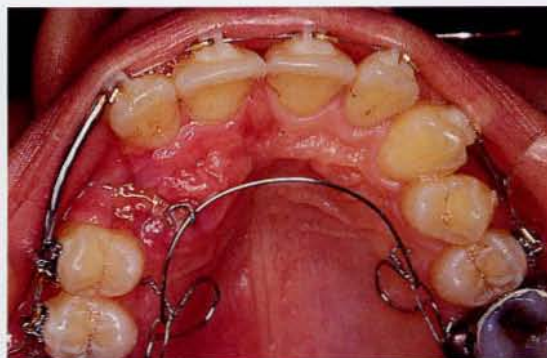
The *auxiliary labial wire* is a third possibility (Fig. 6.29); it requires no advance preparation of any sort, such as the soldering of lingual tubes. It is most conveniently fashioned from an archform blank of 0.014" diameter round wire by forming a vertical loop in the area of the impacted canine. This loop has a small terminal helix. The auxiliary is tied into all the brackets of the arch, in 'piggyback' style, with

the extremities slotted into a spare tube on the molars, or left free distal to the second premolars. In a similar manner to the ballista, the vertical loop is activated by pressing it palatally, across the canine space, and ensnaring it in the pigtail ligature in the palate.

This is a particularly useful method for use with a bilateral impaction, when two different loops will need to be inserted into the arch-



(a)



(b)

Figure 6.28

(a) The active palatal arch in its passive mode, lying several millimetres inferior to the palate and seen from the occlusal.
 (b) The same view after the active palatal arch has been gently raised towards the palate and ensnared by the pigtail hooks, thereby applying vertically extrusive traction to the unseen canines.

form. Used without a base arch (Proffit, 1992; Kokich and Mathews, 1993), it will extrude the adjacent teeth and thereby alter the occlusal plane. It will move the molars buccally, and additionally it will alter the horizontal archform in the incisor area.

A *mandibular removable appliance* represents a method that requires no maxillary appliance at all, in the first instance (Orton et al, 1995). Vertical extrusive force is derived from a removable appliance in the opposing jaw, through the agency of a latex elastic. This elastic is applied by the patient between the clasps of the mandibular appliance and the pigtail ligature in the palate. A maxillary orthodontic appliance is needed only when the tooth has erupted through the palatal mucosa.

Regardless of which method is employed, the successful end-result will find the newly erupted tooth, surrounded by a wide rim of palatal mucosa and bone, in the middle of the palate (Fig. 6.30). The more the tooth is erupted, the easier it will be to place an attachment on its buccal surface to enable the tooth to be moved buccally, without the bracket-impinging on the gingiva. However, an excessively erupted tooth will lead to

occlusal trauma as it moves across the line of mandibular teeth.

For the first stage of the two-stage manoeuvre, the position of the eyelet is immaterial. Therefore bonding is performed to the most convenient surface available, since no adverse rotation of the tooth will occur while it is being moved vertically downwards. The tooth is cleared of the lateral incisor root and moved until it has an unobstructed path to the archwire. A second eyelet is bonded to the tooth, this time on the midbuccal aspect, which will have become accessible as the result of the initial orthodontic movement. The second stage of traction may then commence, with the application of force from the second eyelet directly to the labial archwire.

The point should be made that in this case, and in any other group or situation, direct traction to the archwire should only be performed from an attachment sited in the midbuccal position of the tooth. Traction applied at any other site will engender an unwanted rotation as the tooth progresses towards its place in the arch – a rotation that will require correction in an extra and superfluous phase of orthodontics.



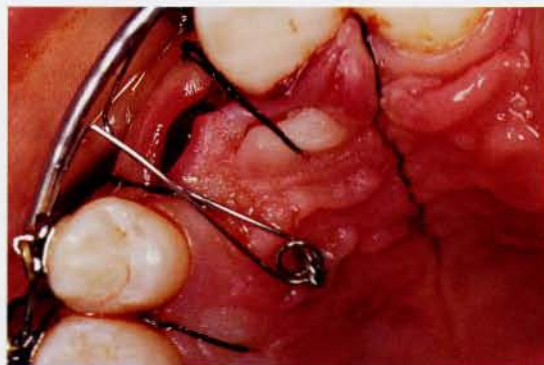
(a)



(b)



(c)



(d)

Figure 6.29

(a) Initial treatment has created space, and a heavy base arch carrying a stainless steel tube space maintainer is in place. (b) A typical auxiliary labial archwire of 0.014" gauge with its vertical loop and terminal helix. (c) The auxiliary labial archwire is tied or pinned into the brackets 'piggyback' over the heavy base arch, immediately prior to surgical exposure. (d) Following the full flap closure, the vertical loop is gently turned inwards and upwards, with its helix secured into the terminal hook of the pigtail. This is the same case as in Fig. 6.25.



Figure 6.30

The tooth has erupted appropriately, and is ready for its buccal traction.

Problems that may be encountered

On occasion, the palatal tissue is very resistant and bulges more and more as the tooth progresses, but does not allow the tooth to erupt (Fig. 6.31d). This eventuality will necessitate a very limited and superficial surgical removal of the thick mucosa immediately over the crown of the tooth. The anterior palatine artery is located in this immediate area, and care should be taken not to sever it, in what is otherwise a very simple procedure.

Once the tooth is well erupted, at the level of the occlusal plane, a new eyelet attachment is bonded to its anatomically buccal surface (Fig. 6.31e). It is then drawn in a direct line to the labial archwire and to the place where space will have been provided for it in the initial orthodontic phase of the treatment. Initial rotation of the canine will still be present when this second phase of the traction begins, but it will correct steadily as the traction proceeds, with the attachment and buccal surface leading the way.

Even with good oral hygiene during the traction period, much exuberant gingival tissue precedes the canine during its migration towards the line of the arch. The premature use of a conventional bracket may result in tissue impingement, particularly as the tooth

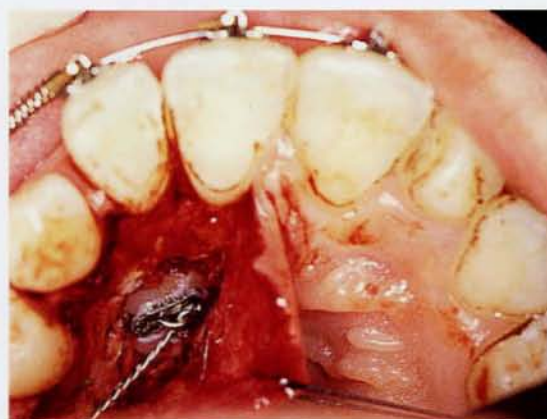
comes into close relation with the adjacent teeth. The orthodontist should not relinquish the use of the eyelet until no further buccal movement is needed.

Complications

The initial location of the tooth may be complicated by one or both of the following conditions.

- (a) *Rotation.* As with the group 1 canine, a mesio-lingual rotation is common, and it is largely corrected during the second stage of resolution, when traction is made from the second eyelet, on the buccal surface of the tooth.
- (b) *Palatally displaced root.* Occasionally a tooth in this group may present with the root palatally displaced, in addition to the crown (i.e. a palatal translation of the entire tooth). Its occurrence will complicate the appliance work by requiring the introduction of buccal root torque and often some mesio-distal root uprighting. These forces may only be applied once the crown has been engaged by the main labial arch wire.

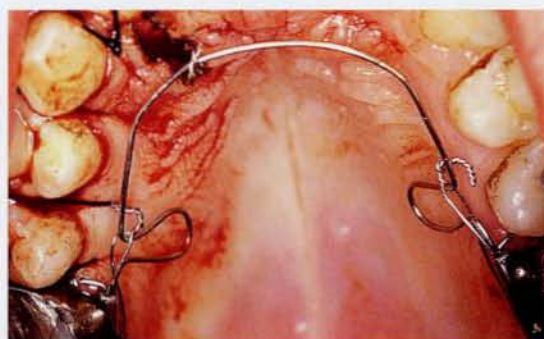
It will be appreciated that a group 2 canine has to be approached with a good measure of preparedness. From the surgical point of view, access is not difficult, but exposure must be performed carefully to avoid damaging the adjacent teeth. The orthodontic appliance may need to execute as many as five different types of movement, involving both crown tipping and root movement, i.e. vertical extrusion from the palate, buccal tipping to the line of the arch, rotation, mesio-distal root uprighting and buccal root torque. From the periodontal point of view, the prognosis of the result is dependent on the smooth execution of the surgical and orthodontic operative procedures. Mismanagement of both the orthodontic and the surgical stages may not be germane to the question of whether the final alignment of the tooth will be technically successful, but it will be critical in determining the final bone level (Figs 6.31j,k) and periodontal condition that may be achieved (Figs 6.31g,h).



(a)



(b)



(c)



(d)

Figure 6.31

(a) A group 2 canine in a 17-year-old female has been minimally exposed on its palatal side. The tip of the cusp has not been exposed. An eyelet attachment has been bonded to the palatal side. (b) Suturing is completed, with the pigtail emerging through the divided flap. The palatal arch is prepared for ligation. (c) The palatal arch fully tied-in and active. (d) Seen 3 months later, after two intervening visits for adjustment, the archwire has become distanced from the palate, and the canine can be seen to bulge the contour of the palate almost to the occlusal level. (e) The deciduous canine was extracted at the same time as the minimal re-exposure was performed, preparatory to buccal movement. A second eyelet is bonded slightly mesial to the mid-buccal position, and elastic ligation is drawing the tooth directly to the archwire, with a favourable rotation vector from the second eyelet. (f) At 13 months post-surgery, the canine is in the arch, and a bracket is substituted for the eyelet. (g, h) The gingival health of the treated canine is good, but its clinical crown is longer than the untreated left canine. (i) The periapical view. Note the resorbed root apex of right lateral incisor. (j, k) Post-treatment periapical views to show comparable bone support of treated and untreated canines.

(Figure 6.31 continued)



(e)



(f)



(g)



(h)



(i)



(j)



(k)

Group 3

- Proximity to line of arch: close
- Position in maxilla: high

The root apex of the canine in this group is situated very high in the maxilla, although most often in the general, bucco-lingual, line of the arch and in its correct location in the antero-posterior plane. The crown is high and only relatively mildly displaced palatally, and it is not usually palpable.

Surgical and orthodontic strategy

Access to this tooth may be either from the buccal side or from the palatal side, with advantages and disadvantages to both approaches, since there is a significant thickness of bone medial and lateral to the tooth. Considerable bone removal is needed to reach it from either side, with similar difficulty in the application of an attachment. The orthodontic treatment entailed in aligning such a tooth involves principally extrusion, together with a buccal tipping movement.

The buccal approach

From the buccal side, the tooth is approached as for a buccal impaction, which was described in Chapter 3. The surgeon may have greater difficulty in locating the impacted tooth, and will be more dependent on the radiographs.

The *apically repositioned flap* (Vanarsdall and Corn, 1977) would, at first sight, appear to be a good approach, since it offers suitable access for the application of orthodontic force direct to the archwire. It also ensures that an adequate band of attached gingiva be raised above the level of the impacted tooth and then accompany that tooth in its subsequent downward path.

From the surgical point of view, however, this approach takes no account of the three-dimensional location of the canine. The method may be very suitable for a buccal canine whose vertical displacement is relatively minor, but in the case of a more superiorly displaced palatal canine this type of exposure would leave a considerable expanse

of alveolar bone open to the oral environment and the flap sutured several millimetres lateral to the crown of the tooth. Furthermore, the maintenance of the exposure of a canine crown, palatal to the line of the arch, would secondarily cause a denuding of the interproximal areas of the roots of the adjacent lateral incisor and first premolar teeth. This method is only suitable for cases of very minor palatal displacement.

Full flap reflection and its subsequent partial replacement over the exposed tooth, together with the placement of a surgical pack, has been used for many years, and was widely advocated (Lappin, 1951; Johnston, 1969; Lewis, 1971; von der Heydt, 1975) for a palatally impacted canine. In the case of a group 3 canine, a considerable thickness of alveolar bone is present both inferiorly and inferio-buccally to the canine, which must be traversed by the tooth. In order to overcome this physical impediment, the above authors have recommended the surgical channelling of bone, to free a path in the direction of the dental arch (Figs 6.32a-c).

Experience with this procedure shows that, while it lives up to its expectations regarding the provision of access and the enablement of direct traction, it does so only by the planned sacrifice of much of the bone of the immediate area of the alveolar process! The treated result (Fig. 6.32d) then leaves an aligned canine with an unacceptably reduced bone support and a much poorer periodontal prognosis than could be achieved by other means.

The tunnel approach

An excellent modification of this method has recently been described (Crescini et al, 1994) in which the buccal plate of bone is preserved, while the impacted tooth is drawn through a tunnel in the bone provided by the vacated socket of the simultaneously extracted deciduous canine (Fig. 6.33a). The same full flap is reflected and the impacted tooth exposed, leaving the buccal plate inferior to it intact. The deciduous canine is extracted, and its socket is extended and widened sufficiently to allow the passage of a fine wire through it as far as the impacted tooth.



(a)



(b)



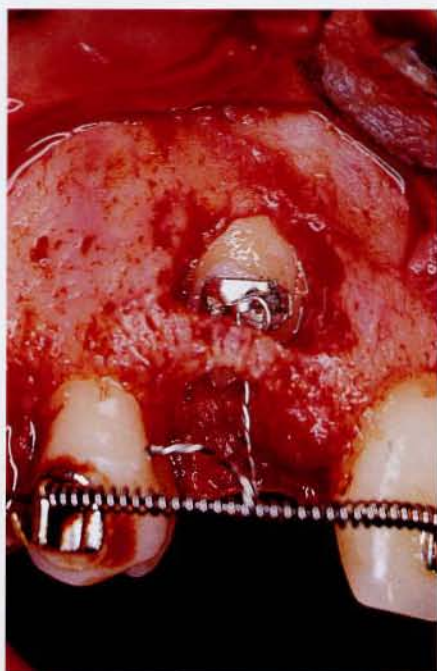
(c)



(d)

Figure 6.32

(a,b) The group 3 canine has been exposed from the buccal side, and bone has been channelled to clear a direct path to the archwire. (c) With the band cemented to the canine, the radical nature of the surgery may be seen. (d) The aligned canine shows a long clinical crown and a lack of normal bony contour. Note the deficient interdental papillae.



(a)



(b)



(c)

Figure 6.33

(a) The 'tunnel' approach. Note the preservation of the buccal plate inferior to the tooth. The stainless steel pigtail is drawn inferiorly through the vacated socket of the deciduous canine. (b) At 2.5 months post-surgery, the 'slingshot' elastic module has brought the canine into a buccally palpable position. (c) 1 year after completion of treatment. Note the gingival height, wide attached gingiva and good bony contour.

An eyelet attachment on steel mesh is threaded with 0.011" soft ligature wire, ready for bonding to the newly exposed impacted canine. Following appropriate acid etching of the enamel surface, the attachment is loaded with the bonding agent, and its steel ligature pigtail is lightly curved and threaded into the immediate area of the exposed tooth and on into the prepared tunnel until it emerges from the occlusal end of the deciduous canine socket. At this point, the eyelet attachment is pressed firmly into place on the impacted tooth.

The surgical flap is resutured to its former place, and visual contact with the impacted tooth is lost. Control of future movement of the canine is exercised through the application of force to the steel pigtail ligature, whose extremity may be seen to extend through the sutured edges of the flap, within the deciduous canine socket. Any excess in its length is cut, and it is fashioned into a small hook, to which elastic traction may be applied.

The surgical method affords good access to the canine and a minor degree of difficulty in

threading the ligature. Orthodontic traction may be efficiently applied, and the treatment result shows a good bony profile and an uncompromised periodontal result, similar to that seen on normally erupted teeth (Crescini et al, 1994).

The palatal approach

With the crown of the canine slightly more palatally displaced, surgery on the buccal side needs to become more radical, rendering a palatal approach preferable.

Following the raising of a palatal flap, the canine will be revealed high up, palatal to the roots of the adjacent teeth, which occasionally may themselves become denuded in the process. Inferior and lateral to the canine is the vertical wall of the alveolar process. Bonding of the eyelet attachment is performed in the usual manner, to the most conveniently accessible site, which is the palatal side of the tooth, although the buccal surface, close to the tip, is occasionally possible.

In this situation, many surgeons will remove a part of the flap in order to leave the impacted tooth in visual contact with the exterior and will place a pack to cover the open area. If the stainless steel pigtail ligature is drawn towards the line of the arch and sutured into place so that its extremity comes through the deficient part of the flap, the application of orthodontic forces will give rise to significant danger of irritation and infection of the area. This is caused by the tooth being drawn buccally and vertically downwards by its ligation to the labial archwire. The resultant direction of this force will cause the impacted canine to be drawn laterally against the alveolus and its healing granulation tissue. The exposed tooth will become reburied in these tissues (Fig. 6.34) as it proceeds downwards and buccally. This leads to inflammation, false pocketing and the likely occurrence of an acute lateral periodontal abscess.

It is therefore advised that orthodontic strategy for group 3 canines be altered, by dividing its resolution into two distinct stages, as with group 2 canines (Fig. 6.35).

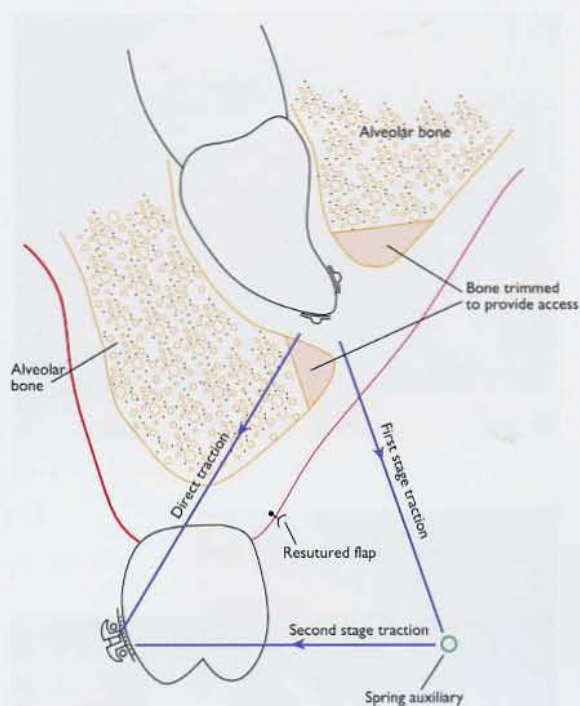
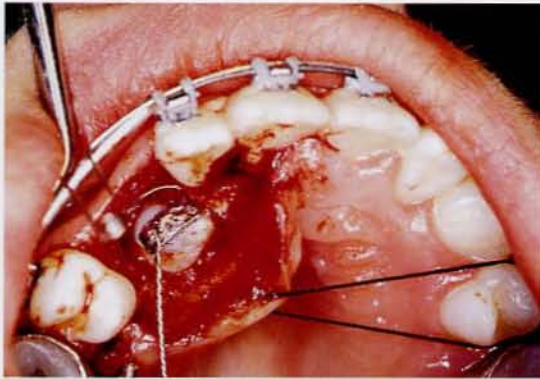


Figure 6.34

Direct traction versus two-stage traction in the group 3 canine.

Orthodontic traction is first applied in the lingual and vertically downward direction, to erupt the tooth into the palate, palatal to the line of the arch and brought down to the occlusal level. As it comes down, it is accompanied by a wide collar of newly formed alveolar bone.

At this point, an additional eyelet should then be placed on the buccal aspect, as for a group 2 case, and the direction of traction altered to a pure buccal tipping movement, to bring it into the arch. It is often possible to bond a conventional bracket to complete this



(a)



(b)



(c)

Figure 6.35

(a) A group 3 canine exposed and viewed from the occlusal aspect to show the attachment bonded near the tip of the buccal side. (b) six weeks later and without further adjustment, the canine has erupted through the closed flap. (c) Buccal traction to the buccally placed eyelet. (d,e) The buccal and palatal views of gingival tissues on the treated side, 16 months post-surgery. (f,g) The same views of the normal side. (h,i) Periapical views of the treated (right) and untreated sides, showing comparable bone support levels.

(Figure 6.35 continued)



(d)



(e)



(f)



(g)



(h)



(i)

second stage if there is enough gingival clearance on the buccal surface of the tooth, although this may not be necessary. Since neither rotation nor ectopic root apex position is common in these cases, the second-stage tipping movement generally brings the canine into its desirable position and inclination.

The canine that is located in the position that we have described here presents different problems from the group 2 cases. Direct traction is, under these circumstances, technically possible, but periodontally hazardous. The most direct surgical remedy (from the buccal side) is too radical and leaves the tooth relatively unsupported by bone, in the final analysis, unless the 'tunnel' approach (Crescini et al, 1994) is used. However, for the palatal approach, careful two-stage orthodontic movement will require minimal surgery and avoid undesirable periodontal sequelae.

The principal feature that distinguishes the group 3 case from the simple and straightforward group 1 case is its relative height in the alveolus. The root apex is usually in the line of the arch, and the crown is only relatively minimally displaced palatally, which often means that the tooth cannot be palpated. The group 1 canine requires a minimal degree of vertical development in the mechanotherapy, and mainly a buccal tipping movement from its more severe palatal position. The group 3 canine, on the other hand, has primarily to be extruded vertically. If only a very minor buccal component is needed then a buccal approach to surgery, using the 'tunnel' method, may sometimes be advantageous.

Group 4

- Proximity to line of arch: distant
- Position in maxilla: high

When the crown of the palatally displaced canine is not directly related to the roots of the incisors, it generally points medially and approaches or even crosses the mid-palatal suture (Fig. 6.36). It is not always palpable in the palate.

Surgery

These teeth are generally at some distance from the adjacent teeth, and little bone removal is needed to expose them, with scant danger of exposing the roots of other teeth. There is usually reasonably good access for the placement of a bonded attachment, although the immediate exposed surface is unlikely to be the buccal aspect of the tooth.

Planning the orthodontic strategy

Since there is normal positioning of the root apex in most of these cases, all that would appear necessary is to draw the tooth directly to the labial archwire. If the long axis of the tooth is close to the horizontal plane, it would be inappropriate to do this, since the direction of this force would be virtually coincident with its long axis. This makes the mechanics highly inefficient, and little progress in resolving the impaction will be seen. The procedure will become excessively taxing on anchorage, and will give rise to a reactive movement of the entire maxillary dentition.

With the tooth close to the horizontal, a more cautious approach should be embarked upon. A wide downward tipping movement will be achieved more efficiently with the same vertical directional approach that has been described for use in group 2 and 3 cases, with the use of spring auxiliaries.

Were the fulcrum for this wide tipping movement of the canine to be at the root end, then it would follow that the root apex position would be unchanged when the crown finally reached its destination in the line of the arch. Unfortunately, however, the fulcrum is usually some short way along the apical portion of the root, and therefore, during the alignment of the tooth, there will be a concomitant palatal displacement of the root apex of the canine. Thus some buccal root torque of the group 4 canine will later be necessary. Therefore it also follows that in the unusual situation where there is a palatal displacement of the root apex at the outset, much torque will be required, and this presents a major clinical problem.

Problems

Torque cannot be applied until the crown of the tooth has reached its place in the arch and its conventional orthodontic bracket firmly engaged by the labial archwire. At that juncture, the crown of the canine is at the occlusal level and has a strong buccal tilt. This places the palatally displaced root low in the palate, with its profile clearly outlined under the mucoperiosteum. That critical portion of the lingual side of the root closest to the crown of the canine has a markedly convex shape, which dictates a distinct bulging of the mucosa covering it. In the clinical context, some dehiscence of this lingual area of the cemento-enamel junction is usually present. Additionally, the cingulum area of the palatal aspect of the crown is very prominent, and is likely to interfere with the occlusion.

It is important to recognize that in group 4 cases and many group 2 cases, considerable lateral movement of the canine is required, most of which involves tipping. Quite frequently, buccal root torque is also needed, and this may be quite considerable, particularly in the present group. Accordingly, there is an equal and opposite reactive force acting over a long period on the entire anchor unit, which, if properly planned and prepared, will respond only minimally. This will be expressed as a movement of the dental midline to the opposite side and a crossbite tendency on the same side. In order to minimize this, a heavy base arch should be used, and its form should be altered to compensate for the expected movements. A bilaterally affected case provides the opportunity for nullifying loss of anchorage by pitting one side against the other, such that midline and archform alterations need not occur.

To summarize the group 4 cases, the clinician must be alert to difficulties in the mechanics that the location of the canine provide. Care must be taken to preserve orthodontic anchorage by properly planning the mechanotherapeutic strategy of reducing the canine displacement. The practical limitations imposed may lead to adverse effects on the

periodontic status of the lingual aspect of the tooth, where occlusal interference may be present in the interim until the root position is corrected.

Group 5

- Canine root apex mesial to that of lateral incisor or distal to that of first premolar.

This tooth should be considered as a transposed tooth. To be completely consistent with the definition of transposition, the canine apex should be in the line of the arch, in the place of the root apex of the adjacent tooth, but it is independent of mesio-distal or buccolingual crown location.

Surgery

Many of the transposed canines are at least partially erupted, which obviates the need for surgery. It is not possible to identify impaction trends among the remainder that might suggest a particular approach to their exposure. Rather, each should be surgically exposed in line with its own particular demands and circumstances. What is true is that several of these may be so displaced that modalities of treatment other than orthodontics should be considered, particularly extraction and prosthetic replacement or, preferably, retention of the deciduous canine.

Planning the orthodontic strategy

The canines in group 5 may be offered four possible lines of treatment that are appropriate procedures for their resolution:

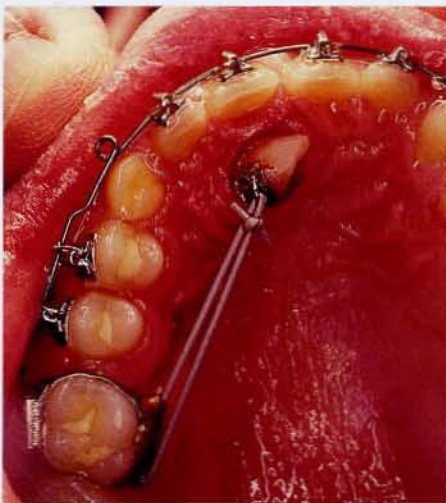
- (a) to resolve the transposition to the ideal relationship (Fig. 6.37);
- (b) to move the premolar mesially (or incisor distally) into the canine location and align the canine between the two premolars (Fig. 6.38);
- (c) to use the canine for autotransplantation into a prepared socket in its ideal site; or
- (d) to extract the severely displaced canine, incisor or premolar, depending upon



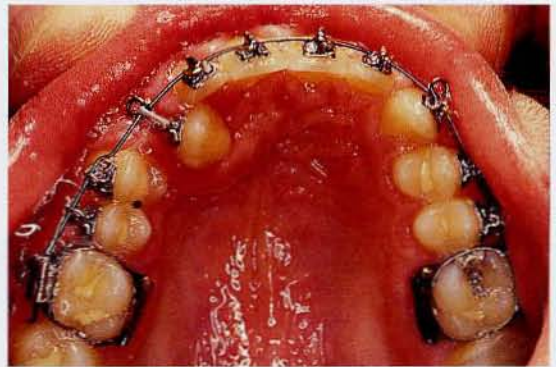
(a)



(b)



(c)



(d)

Figure 6.36

(a) The active palatal arch in place to erupt a group 4 canine that has traversed the midline. (b) Post-surgical periapical radiograph shows space opening and an active palatal arch ligated to the bonded attachment. (c) After 3 months of traction, minimal re-exposure of the now very superficial and palpable canine was performed. A posterior component was achieved using elastic thread to the lingual tube of the molar of that side. (d) Disto-buccal followed by purely buccal traction was also performed. Distal uprighting and buccal root torque were later needed. (e, f) Intra-oral views to compare the buccal gingival health and clinical crown length of the treated (right) and untreated canines. (g,h) The same on the palatal side.

(Figure 6.36 continued)



(e)



(f)



(g)



(h)



(a)



(b)

Figure 6.37

(a,b) A maxillary canine/first premolar transposition, treated to reverse the transposition.

which has the least chance to be aligned with a good prognosis.

Mechanotherapy aimed at reducing transposition and bringing the tooth to its correct position in the dental arch is fraught with difficulty. Whether the crown of the canine is drawn directly towards the labial archwire or only after an initial vertical traction phase, the canine's root will inevitably come into close relation with the root of the adjacent first premolar or lateral incisor. Root contact in group 5 cases creates a mechanical couple. The continued application of force from the labial archwire will draw the crown of the canine ever closer, although with greater difficulty and taking considerably more time.



(a)



(b)



(c)

Figure 6.38

(a,b) Canine/lateral incisor transposition seen intra-orally and on panoramic radiograph. (c) The completed alignment of the teeth in the transposed order. Grinding of the incisal edge of the lateral incisor needs to be performed to avoid occlusal interference and to improve appearance.

Problems that may be encountered

If we assume that the entire canine tooth is palatal to the line of the arch, the secondary effect of the root contact will rotate the canine's root apex, both mesially and palatally, across the palate, in a wide sweeping movement. The tooth will become 'laid out' immediately beneath the periosteum, and the long profile of its root will be palpable under the palatal mucosa. Dehiscence of the cervical area of the root surface will occur (Fig. 6.39). The amount of unavoidable labial root torque that will then be required will be extreme and beyond therapeutic reason. If the canine position is buccal to the root of the adjacent tooth and the tooth is brought buccal to the first premolar or the lateral incisor, further buccal displacement of its root will occur, with gross dehiscence of the buccal periodontium.

To achieve complete and ideal orthodontic alignment of the group 5 canine, while minimizing these severe periodontal consequences, mechanotherapy would need to be aimed at both transposed teeth. The root of one would need to be torqued in a lingual and then distal flanking movement, while the other would need to be torqued in an opposite buccal and mesial flanking movement. In this way, neither would be displaced too far



Figure 6.39

A 'laid-out' canine due to contact of the canine with the root of the premolar during traction. (Courtesy of Dr Y ben Bassat.)

from the line of the arch, and, while each would undoubtedly suffer periodontally, this would be less than either one individually. It would be of great help if a practical method could be devised to perform these difficult movements on an unerupted tooth, while the crown is too distant to be ligated into the labial archwire.

While each of the above four treatment possibilities will be recommended in specific instances, it becomes clear that the most likely and practical course will be to recognize and accept the transposition. The canine should be brought into the dental arch with the first and second premolars (or between central and lateral incisors) as its mesial and distal neighbours respectively.

'Machoism' may be the driving force behind the decision to place the teeth in their correct order, since, after all, we are orthodontists and this is the sort of challenge for which we have been trained. It is difficult to pass over an opportunity to display our initiative, our dexterity and our clinical excellence. Sometimes this is justified – but not often.

It should always be remembered that the reversal of a transposition dictates, of necessity, that the two teeth have to pass by one another in an alveolar process whose bucco-lingual width is suitable for just one of them. True, when teeth are moved buccally or lingually on the ridge, there is a concomitant bucco-lingual expansion of the alveolar bone. Clinically, however, there is loss in bone height, and a dehiscence may occur, particularly if oral hygiene is inadequate. Furthermore, the biomechanics is difficult to perform with adequate root control, and root proximity may occur during the exercise. This could seriously compromise bone support on that surface of the two roots, and some loss of attachment or even root resorption may occur.

Group 6

- Erupting in the line of the arch, in place of and resorbing the roots of the incisors

Why unerupted permanent teeth, which are in close proximity to the roots of their neighbours, cause resorption of the roots of neighbouring teeth is unclear. However, when it does happen, it is aggressive and usually non-symptomatic. The presence of follicular/dentigerous cysts, which may displace the roots of the adjacent teeth, is not generally associated with their resorption (Brin et al, 1993a; Ericson and Kurol, 1987a,b). However, root resorption of the lateral incisor is diagnosed far more frequently when this tooth is of normal size than when it is small or peg-shaped. In other words, in those cases that show the typical picture of associated anomalies described earlier in this chapter, the likelihood that they will exhibit root resorption is small (Brin et al, 1993a).

Given that this type of resorption is rapidly progressive, diagnosis and treatment decisions must be made speedily. The condition constitutes one of the very few situations in which orthodontic treatment may be considered a quasi-emergency.

Periapical radiography will help the clinician to diagnose and assess the degree of existing resorption, but precision in determining the angulation of the tube to the tooth and the film may be critical in these cases. Subsequent radiographic follow-up of (a) the changing position of the canine, which is being elicited by the mechanotherapy, and (b) the progress of the resorption process is the only practical method available to monitor the resolution of the problem. Accordingly, periapical radiographs, taken without regard to standardization, will lead to the drawing of inappropriate conclusions on both scores.

Lateral views of the anterior area of the maxilla (lateral cephalogram or tangential view) may show the profile view of the long axes of the canine and of the affected incisor teeth to be continuous with one another. However, superimposition of other teeth is likely to make this view inconclusive. The vertex occlusal view will confirm that the canine is not displaced buccally or palatally, and, given its overlapping relationship with the adjacent incisor, one may draw the conclusion that root resorption is present and that the canine is in the same bucco-lingual

and mesio-distal plane. In order to achieve the most definitive diagnosis of the extent of the resorption and the position of the associated canines, computed tomography (CT scanning) will be of great help.

According to Ericson and Kurol (1987b), resorption occurs more frequently in palatal canine cases than is generally recorded or noticed by the orthodontist. This would appear to be due to the fact that many of the cases with mild pathology remain undiagnosed. However, these are not the cases that belong to group 6, since the resorption process in minor and superficial areas of root surface will generally cease to be active once the position of the canine has altered, and the long-term prognosis of the canine and the tooth exhibiting the resorption will not be endangered. These cases may be more logically and more conveniently placed in other groups, particularly group 3.

Group 6 is reserved for those canines that are associated with or have the potential for significant loss of root length of the adjacent teeth and that are actually erupting into the area formerly occupied by the disappearing root (Fig. 6.40). As such, they are not generally palpable, since they are situated in the same bucco-lingual plane as the incisors.

The root apex may be close to its ideal position, in the line of the arch. However, the apex-cusp orientation of the canine is almost invariably downwards and mesially, with a slight medial (towards the midline) component. Radiographic views showing the tip of the canine cusp located against and within the resorbed distal side of the incisor root, are very easy to recognize. This type of case requires distal and buccal tipping of the tooth towards the archwire, to distance the two elements from their destructive entanglement. This movement is easy to produce, once the surgeon has exposed only the distal part of the tooth and an attachment has been placed on this surface.

The long axis of the tooth may be pointing obliquely across the incisor root, with the apical half having disappeared in the resorption process. This may now have brought the tip of the crown within the former root area and close to the area of resorptive activity. Distal

and buccal tipping of the tooth towards the archwire is unsuitable, since this always involves some downward movement, which will aggravate the resorption of the more inferiorly placed remainder of the root.

The unchecked advance of the canine may cause total resorption and shedding of one or more of the incisors, and it will place the canine in a finally erupted position, where its appearance is unacceptable and its use as a prosthetic abutment is equally inappropriate, because of angulation.

Surgery and the planning of orthodontic strategy

Two possible escape routes are available to retrieve the crown of the canine from the area, in the effort to salvage as much of the incisor as possible, while improving the position of the canine and its prognosis.

The first route necessitates a palatal surgical approach (Fig. 6.40) to place an attachment on that aspect of the tooth first exposed, with extreme care being exercised not to extend the exposure further than is necessary in any direction. Orthodontic traction is then applied to move the crown posteriorly in the horizontal plane, in a direct line towards the maxillary molars, without incorporating a vertical downward movement. In this way, the crown will follow a posterior and medial circuitous path around the fulcrum of its root apex. Once it has erupted through the palatal mucosa, an eyelet is placed on its buccal aspect and the tooth may be safely drawn to the archwire.

The second route requires an exposure of the tooth from the buccal (Fig. 6.41), erring on the side of a more superior approach, in order to reduce the risk of simultaneously exposing the root of the incisor, which will be in the same bucco-lingual plane. The aim would then be to move the tooth buccally, horizontally and slightly superiorly, over the shortened incisor root stub and to convert it into a buccal canine.

Problems that may be encountered

If the case is first seen very late and root resorption of the incisor has destroyed two-

thirds or more, it is usually more reasonable to remove the incisor and to draw the canine down into its place (Fig. 6.42). The root of the canine will need to be mesially uprighted and probably buccally torqued. It is then reshaped to disguise its original identity and to simulate the absent incisor.

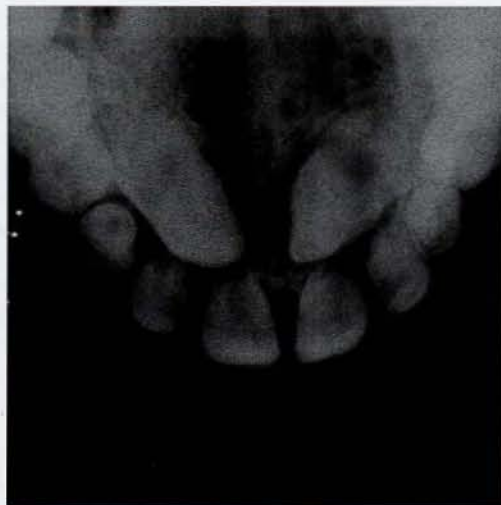
Complications

Does the resorption process stop when the canine has been moved away from the area (Figs 6.41d and 6.43)? Controlled studies of this unusual and special situation have not been undertaken, but clinical experience indicates that it does. This being so, it must be considered worthwhile to plan orthodontic repositioning of the canine, even though the stakes are high, in terms of risk of losing the incisor, notwithstanding the treatment. Indecision and delay are all too easy to encounter, and are often encouraged by the patient, since the condition is usually symptomless. It is only when the final stages of the drama are being played out that the seriousness of the consequences become evident to the patient.

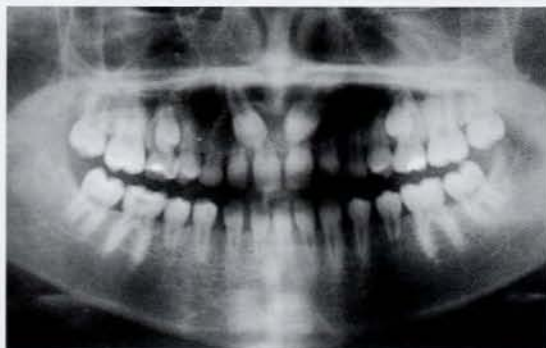
Communication with the patient and the parent, when the patient is a minor, is an essential prerequisite in the treatment plan of even the simplest orthodontic case. In the discussion prior to its commencement, the inherent dangers of treatment, however rare, should be presented together with its potential benefits. This is particularly true in the treatment of cases with impacted teeth, and nowhere is it more apparent than in the cases that we have described as group 6 canines. The discussion should be illustrated with the use of the patient's study models and radiographs, and the risks carefully set off against the potential gain for the patient. This should then be followed up by an individually written letter summarizing the points of the discussion – not just a standard pre-treatment letter. The letter should be given to the patient, and a copy, signed by the patient or the parent (in the case of a minor), should be kept in the records.



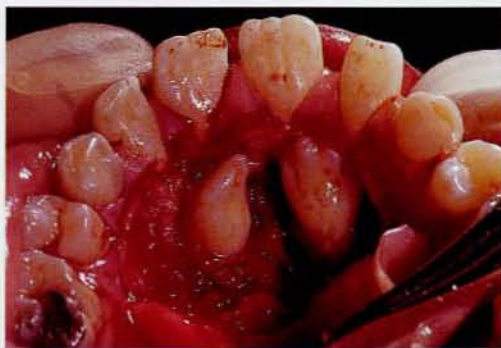
(a)



(b)



(c)



(d)

Figure 6.40

(a–c) From the lateral cephalometric film, the anterior occlusal film and panoramic scan, the canines are seen to be erupting into the place of the resorbing roots of the central incisors in this 15-year-old female. (d) This case was treated 24 years ago, when bands were used and healing by secondary intention, using packs, was routine. Note the use of the soldered palatal arch for force application for posterior traction. (e) The canines have erupted into the palate, well clear of the apices of the incisors. (f) The canines are moved buccally. (g, h) Intra-oral views of the completed result. No brackets were placed on the anterior teeth—the incisors were aligned using the retainers. Therefore necessary root torque of the left canine was not performed. Both laterals shed within a year post-treatment. Some years later, the right canine and both central incisors were incorporated into an extensive fixed bridge. The left canine was extracted because of problems with parallelism. (i) an anterior occlusal radiograph of the (temporary!) fixed bridge, 22 years after completion of orthodontic treatment, showing complete arrest of the resorption process.

(Figure 6.40 continued)



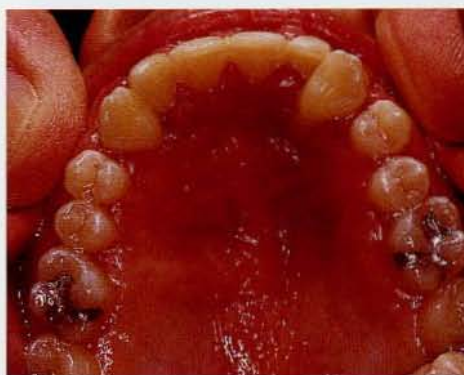
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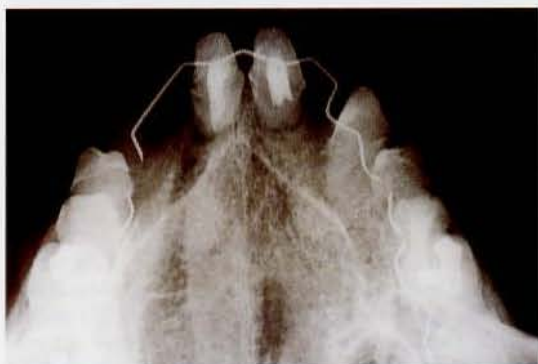
(f)



(g)



(h)



(i)



(a)



(b)



(c)



(d)

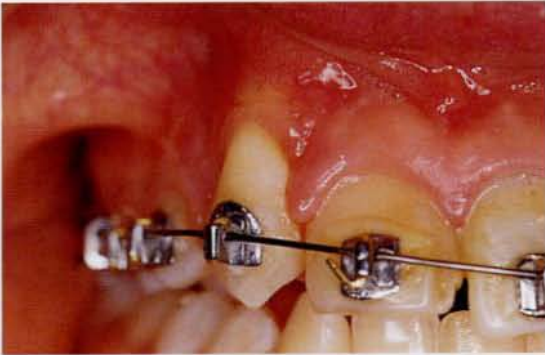
Figure 6.41

(a,b) Periapical views of the group 6 canine with associated severely resorbed central incisor. (c) A variant of the auxiliary labial arch to move a tooth buccally. The loop is drawn upwards and into the sulcus to ensnare the pigtail. (d) Four weeks later, the pigtail has elongated, indicating progress of the canine. (e) After several adjustments over a 3 month period, the eyelet attachment of the canine becomes visible. (f,g) Clinical and periapical views of the final stage of treatment. Note cessation of root resorption of the incisor and the gingival condition of the canine. (h,i) lateral and anterior views 1 year after completion of treatment.

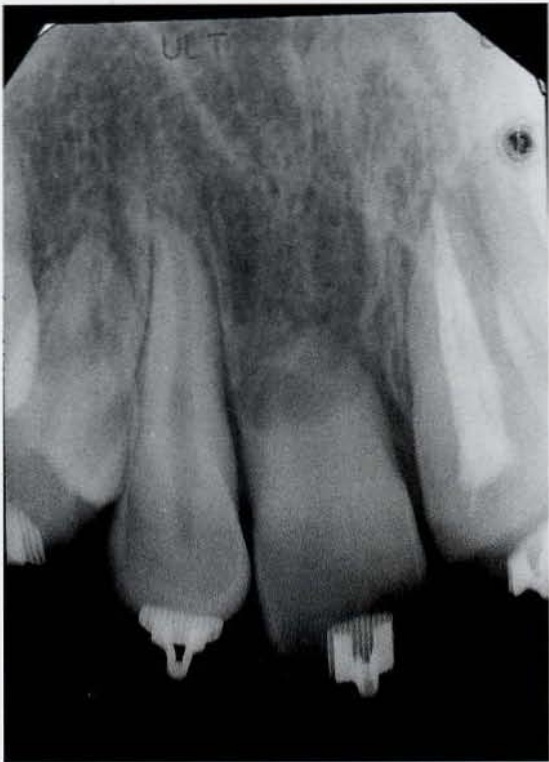
(Figure 6.41 continued)



(e)



(f)



(g)



(h)



(i)



(a)



(b)



(c)

Figure 6.42

(a) The initial condition. (b) A periapical view shows advanced resorption of the central incisor root associated with a canine advancing in a line close to the long axis of the incisor. (c) The incisor was extracted, and appliances are used to erupt the canine into the central incisor position. (Courtesy of Dr T Weinberger.)



(a)



(b)



(c)



(d)



(e)



(f)

Figure 6.43

(a–c) Intra-oral views of a 12-year-old girl, 1 year after trauma had severely damaged the maxillary incisors. The teeth endured several unsuccessful attempts at root canal therapy, and their extraction was recommended. (d) The periapical view shows early oblique apical resorption of the right lateral incisor and the palatally impacted right canine. (e–g) Following the extractions orthodontic space closure was performed and composite build-ups have been placed on the lateral incisors to simulate the extracted central incisors. The remaining maxillary teeth have been moved mesially to close spaces. (h) The periapical view shows no additional root resorption of the lateral incisor, despite its substantial positional change.

(Figure 6.43 continued)

(Figure 6.43 continued)



(g)



(h)

REFERENCES

- Azaz B, Shteyer A (1978) Resorption of the crown in impacted maxillary canine. A clinical, radiographic and histologic study. *Int J Oral Surg* 7: 167-71.
- Bass TB (1967) Observations on the misplaced upper canine tooth. *Dent Pract Dent Rec* 18: 25-33.
- Beck BW, Harris EF (1994) Apical root resorption in orthodontically treated subjects: analysis of edgewise and light wire mechanics. *Am J Orthod Dentofac Orthop* 106: 350-61.
- Becker, A (1978) The median diastema. *Dent Clin N Am* 22: 685-710.
- Becker A (1984) Etiology of maxillary canine impactions. *Am J Orthod* 86: 437-8.
- Becker A (1995) Palatal canine displacement: guidance theory or an anomaly of genetic origin? *Angle Orthod* 65: 95-8.
- Becker A, Zilberman Y (1975) A combined fixed-removable approach to the treatment of impacted maxillary canines. *J Clin Orthodont* 9: 162-9.
- Becker A, Zilberman Y (1978) The palatally impacted canine: a new approach to its treatment. *Am J Orthod* 74: 422-9.
- Becker A, Smith P, Behar R (1981) The incidence of anomalous lateral incisors in relation to palatally-displaced cuspids. *Angle Orthod* 51: 24-9.
- Becker A, Kohavi D, Zilberman Y (1983) Periodontal status following the alignment of palatally impacted canine teeth. *Am J Orthod* 84: 332-6.
- Becker A, Shpack N, Shteyer A (1996) Attachment bonding to impacted teeth at the time of surgical exposure. *Eur J Orthod* 18: 457-63.
- Bjerklin K, Kurol J, Valentin J (1992) Ectopic eruption of maxillary first permanent molars and association with other tooth and develop-

mental disturbances. *Eur J Orthod* 14: 369-75.

Brin I, Becker A, Shalhav M (1986) Position of the maxillary permanent canine in relation to anomalous or missing lateral incisors: a population study. *Eur J Orthod* 8: 12-16.

Brin I, Becker A, Zilberman Y (1993a) Resorbed lateral incisors adjacent to impacted canines have normal crown size. *Am J Orthod* 104: 60-6.

Brin I, Solomon Y, Zilberman Y (1993b) Trauma as a possible etiologic factor in maxillary canine impaction. *Am J Orthod Dentofac Orthop* 104: 132-7.

Broadbent BH (1941) Ontogenic development of occlusion. *Angle Orthod* 1: 45.

Cramer HC (1929) Dental survey of one thousand adult males: a statistical study correlated with physical and laboratory findings. *J Am Dent Assoc* 16: 122.

Crescini A, Clauser C, Giorgetti R et al (1994) Tunnel traction of intraosseous impacted maxillary canines: a three-year periodontal follow-up. *Am J Orthod Dentofac Orthop* 105: 61-72.

Dachi SF, Howell FV (1961) A survey of 3874 routine full-mouth radiographs. II. A study of impacted teeth. *Oral Surg Oral Med Oral Path* 14: 1165-9.

Ericson S, Kurol J (1987a) Incisor resorption caused by maxillary cuspids. A radiographic study. *Angle Orthod* 57: 332-45.

Ericson S, Kurol J (1987b) Radiographic examination of ectopically erupting maxillary canines. *Am J Orthod Dentofac Orthop* 91: 483-92.

Ericson S, Kurol J (1988a) Resorption of maxillary lateral incisors caused by ectopic eruption of the canines. A clinical and radiographic analysis of predisposing factors. *Am J Orthod Dentofac Orthop* 94: 503-13.

Ericson S, Kurol J (1988b) CT diagnosis of ectopically erupting maxillary canines - a case report. *Eur J Orthod* 10: 115-20.

Ericson S, Kurol J (1988c) Early treatment of palatally erupting maxillary canines by extraction of the primary canines. *Eur J*

Orthod 10: 283-95.

Fearne J, Lee RT (1988) Favourable spontaneous eruption of severely displaced maxillary canines with associated follicular disturbance. *Br J Orthod* 15: 93-8.

Freeman RS (1994) Adult treatment with removal of all four permanent canines. *Am J Orthod Dentofac Orthop* 106: 549-54.

Friel ES (1949) Migration of teeth. *Dent Rec* 69: 74.

Hitchin AD (1956) The impacted maxillary canine. *Br Dent J* 100: 1-12.

Howard RD (1967) The unerupted incisor. A study of the postoperative eruptive history of incisors delayed in their eruption by supernumerary teeth. *Dent Pract Dent Rec* 17: 332-41.

Ingber SJ (1974) Forced eruption. Part II. A method of treating non-restorable teeth - periodontal and restorative considerations. *J Periodont* 45: 199-206.

Jacoby H (1979) The ballista spring system for impacted teeth. *Am J Orthod* 75: 143-51.

Jacoby H (1983) The etiology of maxillary canine impactions. *Am J Orthod* 84: 125-32.

Johnston WD (1969) Treatment of palatally impacted canine teeth. *Am J Orthod* 56: 589-96.

Kohavi D, Becker A, Zilberman Y (1984a) Surgical exposure, orthodontic movement and final tooth position as factors in periodontal breakdown of treated palatally impacted canines. *Am J Orthod* 185: 72-7.

Kohavi D, Zilberman Y, Becker A (1984b) Periodontal status following the alignment of buccally ectopic maxillary canine teeth. *Am J Orthod* 85: 78-82.

Kokich VG, Mathews DP (1993) Surgical and orthodontic management of impacted teeth. *Dent Clin N Am* 37: 181-204.

Kornhauser S, Abed Y, Harari D, Becker A (1995) The resolution of palatally-impacted canines using palatal-occlusal force from a buccal auxiliary. *Am J Orthod Dentofac Orthop* 110: 528-34.

Lappin MM (1951) Practical management of

- the impacted maxillary canine. *Am J Orthod* 37: 769-78.
- Lewis, PD (1971) Pre-orthodontic surgery in the treatment of impacted canines. *Am J Orthod* 60: 382-97.
- Lindauer SJ, Rubinstein LK, Hang WM et al (1992) Canine impaction identified early with panoramic radiographs. *J Am Dent Assoc* 123: 91-7.
- Loberg EL, Engstrom C (1994) Thyroid administration to reduce root resorption. *Angle Orthod* 64: 395-400.
- Mead SV (1930) Incidence of impacted teeth. *Internat J Orthod* 16: 885-90.
- Miller BH (1963) The influence of congenitally missing teeth on the eruption of the upper canine. *Dent Pract Dent Rec* 13: 497-504.
- Montelius GA (1932) Impacted teeth. A comparative study of Chinese and Caucasian dentitions. *J Dent Res* 12: 931-8.
- Mossey PA, Campbell HM, Luffingham JK (1994) The palatal canine and the adjacent lateral incisor: a study of a West of Scotland population. *Br J Orthod* 21: 169-74.
- Oliver RG, Mannion JE, Robinson JM (1989) Morphology of the maxillary lateral incisor in cases of unilateral impaction of the maxillary canine. *Br J Orthod* 16: 9-16.
- Orton HS, Garvey MT, Pearson MH (1995) Extrusion of the ectopic maxillary canine using a lower removable appliance. *Am J Orthod* 107: 349-59.
- Peck L, Peck S, Attia Y (1993) Maxillary canine-first premolar transposition, associated dental anomalies and genetic basis. *Angle Orthod* 63: 99-109.
- Peck S, Peck L, Kataja M (1994) The palatally displaced canine as a dental anomaly of genetic origin. *Angle Orthod* 64: 249-56.
- Peck S, Peck L, Kataja M (1995) Palatal canine displacement: guidance theory or an anomaly of genetic origin? Sense and non-sense regarding palatal canines. *Angle Orthod* 65: 13-17.
- Poumparos E, Loberg E, Engstrom C (1994) Thyroid function and root resorption. *Angle Orthod* 64: 389-94.
- Power SM, Short MBE (1993) An investigation into the response of palatally displaced canines to the removal of deciduous canines and an assessment of factors contributing to favourable eruption. *Br J Orthod* 20: 215-23.
- Proffit WR (1992) *Contemporary Orthodontics*. Mosby Year Book, St Louis.
- Stern N, Becker A (1980) Forced eruption: biological and clinical considerations. *J Oral Rehab* 7: 395-402.
- Takahama Y, Aiyama Y (1982) Maxillary canine impaction as a possible microform of cleft lip and palate. *Eur J Orthod* 4: 275-7.
- Thilander B, Jacobson SO (1968) Local factors in impaction of maxillary canines. *Acta Odont Scand* 26: 145-68.
- Vanarsdall RL, Corn H (1977) Soft-tissue management of labially positioned unerupted teeth. *Am J Orthod* 72: 53-64.
- von der Heydt K (1975) The surgical uncovering and orthodontic positioning of unerupted maxillary canines. *Am J Orthod* 68: 256-76.
- Zilberman Y, Cohen B, Becker A (1990) Familial trends in palatal canines, anomalous lateral incisors and related phenomena. *Eur J Orthodont* 12: 135-9.

7 OTHER SINGLE TEETH

CONTENTS • Buccally impacted canines • Mandibular canines • Mandibular second premolars • Maxillary second premolars • Maxillary first molars • Mandibular second molars • Impaction and crown resorption • Infraocclusion of permanent teeth • Dentigerous cysts

Aside from the third molars, the maxillary canines and central incisors are the principal teeth that may become impacted, but, from time to time, other teeth may also be affected. For some of these teeth, familiar patterns emerge, typically affecting the same tooth and with the same aetiology in many of the cases. In others, unusual pathology is involved, which may affect any tooth or group of teeth and is therefore quite unspecific. Nevertheless, even with a widely heterogeneous group, trends may be recognized and treatment protocols may be suggested to cover a good proportion of them.

BUCCALLY IMPACTED MAXILLARY CANINES

As we have pointed out in Chapter 6, crowding is the principal cause of buccally displaced canines, and the scenario by which it occurs was described there. In a small number of cases, the canine's eruption is delayed or interrupted, and remains in its very palpable and unerupted buccal position indefinitely. In others, it may erupt higher up in the

area of the sulcus oral mucosa, which creates a poor gingival attachment. From the periodontal point of view, having only thin oral epithelium covering the root leaves the patient with a delicate and easily traumatized attachment apparatus. Surgical and orthodontic treatment were described in Chapter 3 to resolve the problem.

Occasionally, one may see a patient in whom the unerupted canine is on the buccal side of the alveolus, with its crown very high and strongly mesially displaced, labial to the lateral and central incisor root apices. Although these are usually palpable, the unusual height of the tooth in the sulcus may lead to the clinical diagnosis being missed. Because of the oblique angle at which the X-ray cone is directed, the periapical radiographs will produce a misleading picture that shows the superimposition of the ectopic tooth more inferiorly depicted on the root of the lateral incisor, giving it the appearance of its being palatally displaced.

Surgical access is good, but the ability to provide a satisfactory orthodontic strategy to reduce the impaction is poor. This is because the high buccal canine tooth must be brought inferiorly and buccally, in a manner that

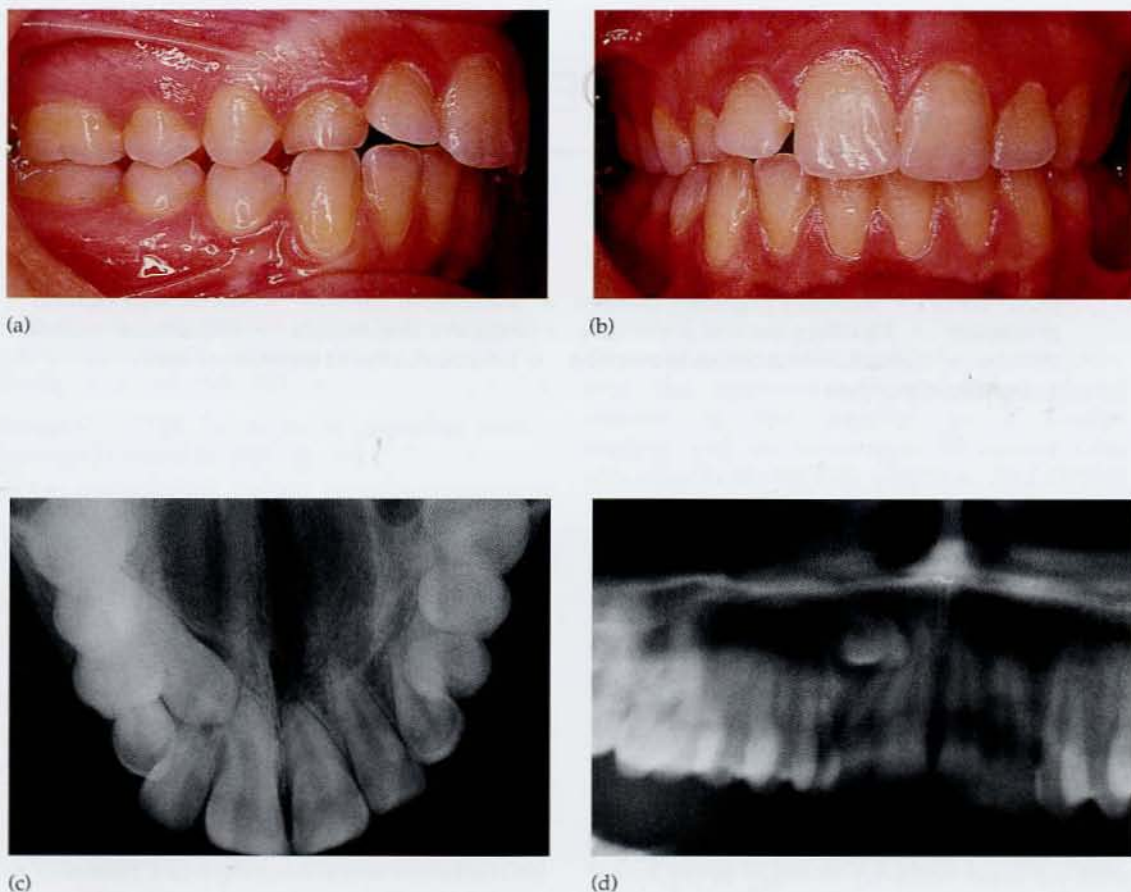


Figure 7.1

(a, b) Clinical views showing an over-retained deciduous right maxillary canine. Note the labial and distal tipping of the right lateral incisor crown and palatal root position. (c) Anterior occlusal view showing superimposition of canine crown and lateral incisor root on right side. Given the palatal root displacement of the lateral incisor, the canine could be inferior to the lateral's root on the palatal side or superior to the root on the labial. (d) A section of the panoramic view, to show the severe mesial displacement and unusual height of the canine. Taken together with the anterior occlusal view, this shows the canine to be buccal. (e, f) Parallax views confirm the buccal diagnosis. (g, h) Extraction of right deciduous and permanent canines only and maxillary arch mechanotherapy has achieved space closure, and good intercuspation in class 1 on the left and in class 2 on the right, with midline correction.

(Figure 7.1 continued)



(e)



(f)



(g)



(h)

circumvents the root of the adjacent incisor. This would involve its being drawn in a semi-circular flanking movement, around the lateral incisor root, in an area where the alveolar bone is too narrow to allow one root to pass by another. As the canine is moved labially, the labial plate of bone thickens and also remodels labially. However, it does so to a lesser extent than the dental movement, until the root of the tooth no longer has a labial plate and is covered only with gingival soft tissue. The prospects for muco-gingival surgery, performed at the time of exposure, are very limited for the high buccal canine,

and so we must expect to see a long clinical crown and a poor prognosis for the tooth in this position (Kohavi et al, 1984).

As a general rule, the more seriously displaced buccal canines of this type are best extracted and, as far as possible, the deciduous canine left in place, preferably with its crown prosthetically enlarged. If the deciduous canine has a poor prognosis, an early decision regarding space closure should be made. Where appropriate, controlled orthodontic space closure may then be carried out, with or without a compensating extraction on the opposite side (Fig. 7.1).

MANDIBULAR CANINES

Since they are very infrequent, little may be found in the dental literature about the impaction of mandibular permanent canines, aside from the odd case report. They seem to occur mainly in association with an unerupted deciduous predecessor; however, they are sometimes seen long after the deciduous tooth has shed normally and there is a relative shortage of space in the immediate area. They may also be found to be present as the result of an obstruction, such as a supernumerary tooth or odontome. Often located on the lingual side of the alveolar process, they will appear as a palpable hard swelling under the lingual mucosa, although they may equally be found buccally ectopic or in the general line of the arch.

The periapical radiograph will most often provide adequate qualitative information regarding the mandibular canine, unless it is very deeply displaced. This is because it may not be possible to insert the film sufficiently deeply into the lingual sulcus. In these cases, an anteriorly rotated lateral oblique film may provide a better view of the tooth. Since these two views are taken close to the horizontal plane, a true occlusal view will be needed to accurately localize the tooth.

Just occasionally, a single mandibular canine may be grossly displaced, mesially and deep in the basal area of the mandible. Its axial orientation is horizontal, with the crown close to or actually crossing the midline symphysis (Fig. 7.2). In this type of case, extraction will be the only practical line of treatment available. Given the presence of the roots of adjacent teeth immediately superior to it and the narrow dimensions of the mandible, there is no room for successful orthodontic manoeuvre, unlike a similar anomaly occurring in the maxillary arch.

For most impacted mandibular canines, however, a careful radiographic evaluation will indicate a reasonable prospect for alignment (Fig. 7.3). In line with the general principles that were set out in Chapter 4, an orthodontic appliance is placed and space is prepared in the arch to accommodate the tooth before its exposure is undertaken (Fig. 7.4).

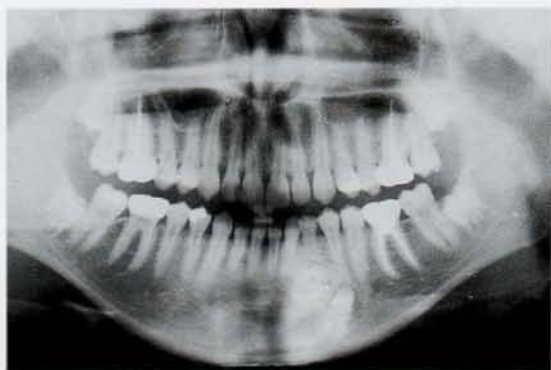


Figure 7.2

The crown of the horizontally impacted right mandibular canine overlies the root of the erupted mandibular canine of the opposite side. (Courtesy of Dr T Weinberger.)

The initial levelling and space-opening archwires are replaced by a heavier base arch, which will provide the anchorage for the desired traction. A measured piece of stainless steel tubing is threaded over the archwire and ligated between the first premolar and lateral incisor to act as a space maintainer.

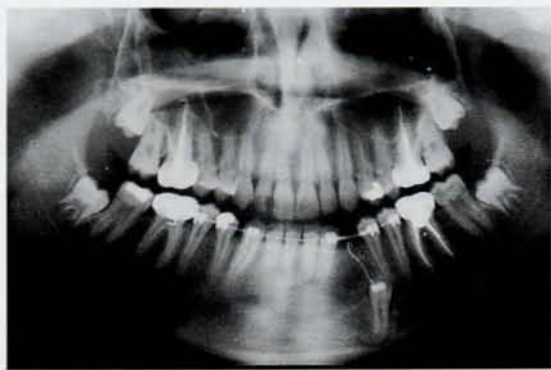
A lingually displaced canine is usually best exposed, an attachment bonded to its buccal aspect and the wound fully closed with the resutured flap, unless the tooth is very superficial. In this way, traction from the attachment direct to the labial archwire may provide the two directional components of force, i.e. buccal and extrusive, that are needed to bring it to its place. The wire ligature pigtail, which was tied to the bonded attachment at the time of surgery, is rolled downwards to form a loop, close to the resutured gingival tissues. An elastic chain is placed across the span between first premolar and lateral incisor, and its middle portion is stretched downwards with a haemostat or ligature director and ensnared in the rolled down pigtail. This provides an easily measurable, light and vertically directed force on the impacted tooth, with a wide range of action.



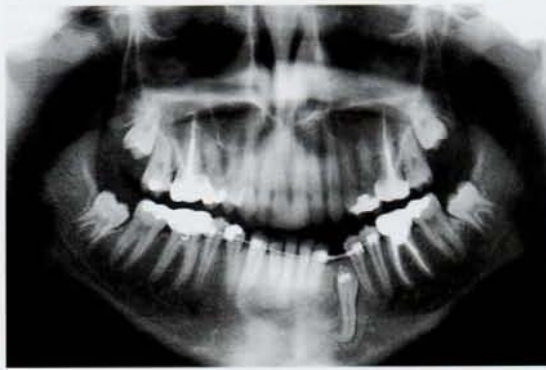
(a)



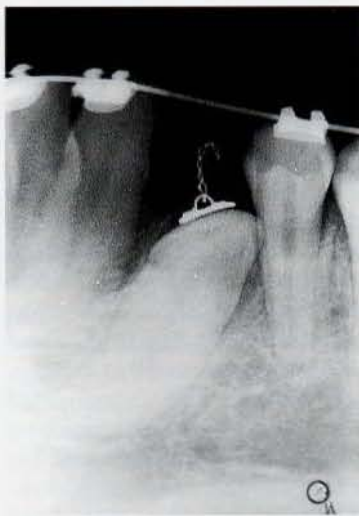
(b)



(c)



(d)



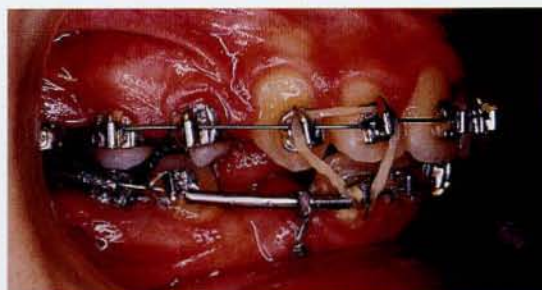
(e)

Figure 7.3

(a) The left mandibular canine has been grossly displaced distally and inferiorly, because of an odontome, and is in close association with the lower border of the mandible. (b) A true occlusal view of the canine/premolar area. (c) After alignment and space opening, surgical removal of over-retained deciduous tooth and odontome has permitted attachment placement. (d) Rapid improvement in position has occurred. Note the deleterious effects on arch form and midline due to use of base arch of inadequate size. (e) A periapical view in the latter stages of resolution. (Courtesy of Dr R Romano.)



(a)



(b)



(c)

Figure 7.4

(a) Exposure of right mandibular canine with dentigerous cyst. Eyelet attachment in place. (b) Fully closed and healed tissue. Note the use of vertical elastic in latter stages, to prevent bite opening. (c) Final detailing of root position.

Transposition

A special case may be made for the buccally displaced mandibular canine, transposed mesially to the lateral incisor. This is not an uncommon form of transposition. The crown of the canine will need to be moved buccally, in order to sidestep the lateral incisor root, before being moved towards the archwire. As with the parallel situation in relation to the buccally displaced maxillary canine, that we have described above, the orthodontic and periodontic prognoses of treatment for these teeth deteriorates in inverse relation to the amount and type of mechanotherapy used.

For these teeth, there remain three alternative lines of treatment for the non-crowded case. The clinician may

- (a) extract the canine, leaving the deciduous canine in its place, provided its root is of reasonable length and prognosis;
- (b) extract the lateral incisor and align the canine in its place, leaving the deciduous canine in place;
- (c) deliberately align the two teeth in a transposed relationship, which, in the mandibular arch, may offer the optimal solution (Brezniak et al, 1993).

In the event of crowding, extraction of the deciduous canine and the permanent canine, or of the deciduous canine and the adjacent permanent incisor, is usually most appropriate. The space provided may then be used for the relief of crowding, as part of an orthodontic treatment programme for other aspects of the malocclusion.

MANDIBULAR SECOND PREMOLARS

Crowding and space loss

Perhaps the most common cause of impaction of the second mandibular premolar is the early extraction of its deciduous predecessor, although this has become less frequent with the decline of caries in the western world. If this loss occurs in the very young patient, up to the early mixed dentition stage, there will be considerable tipping and drifting of the first molar in a mesial direction. Additionally, there will be a degree of distal drifting of the first deciduous molar of the same side, such that the space for the second premolar may be totally eliminated, before it has the chance to erupt.

The result will be that this successional tooth will be blocked from erupting into the dental arch. Its early developmental position being slightly lingual to the line of the arch and its being prevented from developing superiorly in the normal manner, it will either move more lingually and erupt on the lingual side, or it may remain impacted and beneath the 'pitched roof' formed by the two adjacent erupted and tilted teeth.

The radiographic method for these cases is very similar to that described for mandibular canine teeth. The periapical film is used to provide detail, but is also a true horizontal view in this area. Therefore it may be supplemented by an occlusal view, to enable accurate localization.

Space has to be provided for this tooth, which is usually achieved by the extraction of the adjacent premolar, within the context of an overall extraction programme aimed at resolving existing crowding in the entire dentition. Alternatively, the drifted teeth must be resited in their ideal positions, using a fixed orthodontic appliance, with a coil spring compressed between the first molar and first premolar brackets. This may require that the anchorage be supported by an extra-oral headgear in the opposing jaw, through the agency of intermaxillary (Class III) elastics, to prevent mesial migration of anterior teeth.

By whichever method space is made, the tooth will normally erupt with considerable speed, without further assistance.

A third alternative, of course, is to extract the impacted tooth and align the others into whatever space remains, usually together with extractions made in each of the other dental quadrants. From the periodontal point of view, excision of unerupted mandibular second premolars may leave a marked bony defect in the area, even after the adjacent teeth have been fully uprighted.

Abnormal premolar orientation

The second deciduous molar of the lower jaw has much to answer for in relation to the non-eruption of its permanent successor, not merely when it is prematurely lost owing to the ravages of caries, but also when there is a prolonged presence. The second premolar tooth germ is not always in its ideal developmental position, directly between the mesial and distal roots of the deciduous molar. Indeed, an abnormal angulation or location seems to be quite frequent.

The premolar may often be tipped more distally and initiating resorption of only the distal root, leaving the mesial root of the deciduous molar largely unresorbed. This will lead to over-retention of the deciduous tooth – often despite the complete disappearance of the distal root and much of the dentine from within the crown. A periapical radiograph will show the premolar very superiorly positioned, almost inside the distal part of the crown of the deciduous tooth, but a long and thin spicule of the mesial root remains, grimly resisting exfoliation. A parallel scenario may occur with a resorption of the mesial root due to mesial tilt of the second premolar from early on in its development, although it seems to enjoy a lower frequency. In either of these cases, for as long as the degree of tilting is relatively slight and the tooth is relatively high up in the alveolus, the extraction of the deciduous tooth will usually suffice to achieve the rapid and trouble-free eruption of the premolar tooth. Space is never a problem in these cases, since the second premolar has a smaller mesio-distal crown width than its healthy predecessor.

A premolar tooth that has a stronger distal tilt is usually situated more apically, and the distal-occlusal aspect of its crown is in close relation with the mesial aspect of the mesial root of the first permanent molar (Fig. 7.5). The second deciduous molar is over-retained at the time of detection and more than adequately holding the space in the arch.

In these cases, a space-holding device should be used when the deciduous molar is removed, to prevent molar tipping, and an attempt should be made to upright the premolar. A device may be designed in many ways, but

classically a buccal and lingual bar may be soldered to two bands to form a simplified fixed bridge, which is then cemented to these teeth. A single rigid bar, with a mesh pad at each extremity, may be bonded to the buccal surface of first molar and first premolar, and is a fairly good alternative, provided that it is well clear of the occlusion, although, even in this situation, it may still be displaced by occlusal forces transferred by bulky and hard foods.

At surgery, the impacted premolar tooth is exposed in its mesial and occlusal aspects only, and, where possible, an eyelet should be



(a)



(b)



(c)

Figure 7.5

(a) A late developing left second premolar, horizontally oriented. (b) A year later, the tooth has moved distally to overlap the mesial root of the first permanent molar. (c) Extraction reveals some resorption of the mesial root of the molar. (Courtesy of Professor Y Zilberman.)

bonded to this area of the crown of the tooth. Since the tooth is fairly deep down, the flap is completely sutured back into its place, and the stainless steel ligature wire pigtail, tied to the bonded eyelet, becomes the means of applying force to the unerupted tooth. This is applied from an elastic module stretched between a hook on the fixed band of each of the two erupted teeth, parallel to and overlying the rigid bar. The greater the degree of movement required, the more substantial must be the anchor base, and, in these instances, a fixed lingual arch to the opposite molar is preferable.

This area does not provide easy access to permit acid-etch bonding (Fig. 7.6), and, on occasion, eyelet attachment will not be possible. When this is the case, compromises may have to be made in order to salvage the tooth. Wider exposure is indicated (Fig. 7.7), and a buccal or lingual extension to the exposure may be needed. The crown of the premolar should be packed with gauze impregnated with Whitehead's varnish, particularly in the distal area, where the pack will need to be wedged between the premolar crown and molar root. The pack should be sutured in and left for two or three weeks to prevent healing over of the gingival tissues. The deliberate wedging of gauze into the distal area helps to divert the eruption path of the premolar in a more mesial direction, and subsequent eruption usually occurs. As was pointed out in Chapter 3, however, these procedures will make the establishment of an ideal periodontium unlikely, and it is expected that the clinical crown of the tooth will, in the final erupted position, be longer and the prognosis poorer than normal.

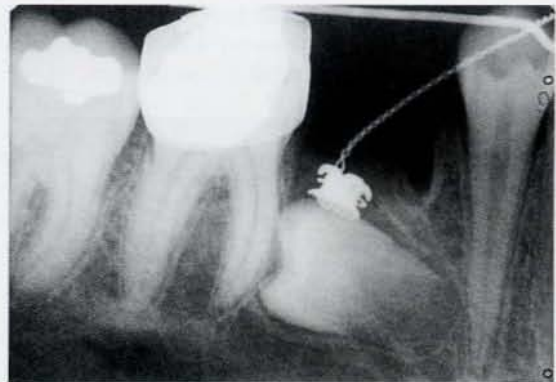
While there are many impacted second premolars that may be treated in this way, success cannot be expected in some of the more extreme cases, and the tooth has to be extracted (see Fig. 7.5).

Infraoccluded second deciduous molars

These are a relatively common occurrence, and are known to shed quite normally in



(a)



(b)



(c)

Figure 7.6

Serial periapical views of a failed attempt to bond an Edgewise bracket to an inadequately developed second mandibular premolar. (Courtesy of Dr D Harary.)



(a)



(b)



(c)



(d)

Figure 7.7

(a) Panoramic view of a case complicated by maxillary impacted canines, late-developing mandibular second premolars and total space loss on the left side. (b) A periapical view shows bonding of an attachment to the right second premolar was achieved only after wide exposure. (c) A similar follow-up radiograph shows improvement in the position of the tooth, but crestal bone height is deficient. (d) A panoramic view of the final stages of treatment clearly shows the reduced periodontal prognosis of the right mandibular second premolar. (Courtesy of Dr L Rothstein.)

most cases, with only a relatively minor delay in their exfoliation time (Kurol, 1984; Kurol and Thilander, 1984). Nevertheless, when the infraocclusion is very marked, an extreme vertical displacement of the apically placed successor will be present. Indeed, the apex of the root of this developing tooth may even

cause a palpable prominence in the otherwise smooth profile of the lower border of the mandible (Becker and Shochat, 1982). In these cases, it is quite impractical to attempt to bond an attachment to these grossly displaced premolar tooth.

Fortunately, with infraoccluded teeth,

actual space loss within the mandibular dental arch is very minimal (Becker and Karnei-R'em, 1992a,b; Becker et al, 1992) and this rarely provides a problem within the orthodontic strategy. However, once the infraoccluded tooth has been removed, space loss may be quite rapid, and a space maintainer should be placed. No attempt should be made in the first instance to uncover the very deeply placed premolar, but, following the removal of the deciduous tooth, the patient should be followed up over a long period of time, with an occasional periapical radiograph taken to check for eruption progress (Fig. 7.8).

Few clinicians have recorded their experience with these extreme cases in the literature, and opinions are strongly influenced by single case treatments. However, there would appear to be some merit to a 'wait-and-see' policy and some reason for optimism in these very special circumstances. Infraoccluded deciduous teeth are associated with a lack of alveolar bone height in the immediate area. The height from the inferior border of the mandible to the occlusal table is significantly reduced when compared with a normal unaffected opposite side (Becker and Karnei R'em, 1992b).

Extraction of the infraoccluded tooth initially leads to healing and bone reorganization, which, in the absence of permanent teeth, will not increase the vertical height of the body of the mandible in that area. If a permanent tooth is present and then begins to erupt, alveolar bone development occurs before and immediately following the eruption, and the vertical bony deficiency is eventually made good. However, this may be partial only, and a lateral open bite may sometimes persist (Fig. 7.9).

MAXILLARY SECOND PREMOLARS

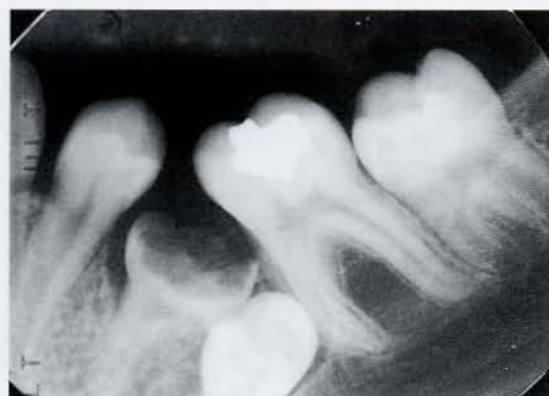
The most common reason why these teeth become impacted, as with the mandibular second premolar, is related to space loss in the dental arch, following the early extraction

of the deciduous second molar and the drifting of the two adjacent teeth, particularly the first permanent molar. It is also true that mesial movement of the first permanent molar in the maxilla is more rapid than in the mandible, it more completely closes off the space, and it does so even in the late mixed dentition stage. Therefore, when space has been lost, the maxillary second premolar is most often to be seen developing with its root in the line of the arch, and with its crown deflected palatally and palpable on the palatal side of the alveolar process.

Infraocclusion sometimes affects the maxillary deciduous second molar too, and, when this is in its severest form (Fig. 7.10), the successional second premolar seems frequently to be displaced both palatally and more mesially than usual. It is often rotated and located high in the maxilla, beyond the area where it may be expected to be palpable.

Because of the oblique angle of the X-ray tube in periapical radiography of this area, the palatally tipped and unerupted second premolar will be viewed almost through the long axis, and will be depicted on the film as an ellipse. This being the case, it is probable that further X-ray films are unnecessary, particularly if the tooth is palpable in the palatal area. While the conventional (oblique) occlusal film or a second, laterally shifted, periapical film will offer the opportunity to add three-dimensional information, the true vertex view would be more decisive.

In general, and quite regardless of the aetiology, second premolars in the maxillary arch will erupt spontaneously, and, as this happens, they also spontaneously resolve their palatal displacement. The only essential requirement is that there be adequate space in the arch and that this space be maintained (Fig. 7.10b). Most often, the second premolar does not need to have an attachment on it, nor is it usually necessary to even expose it. Unlike other teeth, there appears to be little benefit in going through the elaborate orthodontic and surgical preparations that we have described in relation to incisor and canine teeth. Little harm will be inflicted by the exposure and bonding of an attachment, but the exercise will almost always be shown to



(a)



(b)



(c)



(d)



(e)

Figure 7.8

A series of periapical views of an impacted second premolar, displaced inferiorly by an infraoccluded deciduous second molar: (a) the initial view; (b) after space reopening; (c) after extraction and space maintainer placement; (d) spontaneous improvement; (e) the erupted tooth. No other orthodontic procedures were initiated. (Courtesy of Professor Y Zilberman.)



(a)



(b)



(c)

Figure 7.9

(a,b) Intra-oral views of a case in which the left mandibular first and second deciduous molars had been infraoccluded and were extracted 18 months earlier. Eruption was initially rapid, but incomplete and further eruption has not occurred. (c) Panoramic view of case. (Courtesy of Dr M Barzel.)



(a)



(b)

Figure 7.10

(a) Characteristic extreme tipping of the teeth adjacent to an infraoccluded maxillary deciduous second molar. The second premolar is displaced superiorly and mesially, exhibiting a marked distal orientation. (b) Space regaining and maintenance, with extraction of the infraoccluded deciduous molar, has resulted in spontaneous correction of tooth position. Eruption is imminent.



(a)



(b)



(c)



(d)

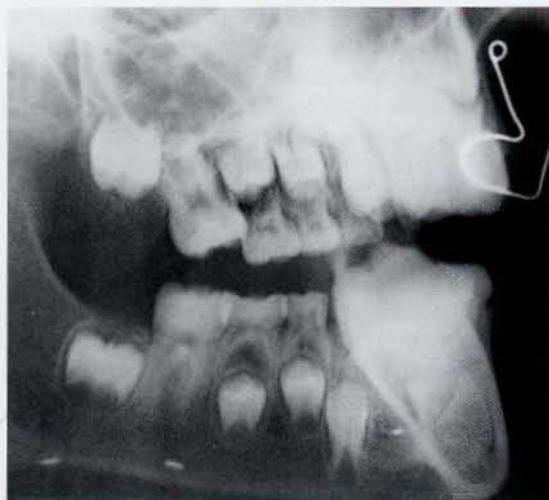


(e)

Figure 7.11

(a) Incomplete eruption of the maxillary first permanent molar, due to abnormal angulation of its long axis. It has become impacted beneath the distal bulbosity of the deciduous second molar. (b) The removable appliance carries five retention clasps and a palatal 'finger' spring that traverses the occlusal surface of the partially erupted first molar. An acrylic button is placed on that portion of the spring that comes into contact with the occlusal surface of the first molar. (c) The incompletely seated appliance shows the spring in its passive mode, distal to the molar. (d) The patient has brought the spring mesially, prior to fully seating the appliance. (e) The molar is disimpacted and in full (Class II) occlusion. (f, g) Lateral oblique extra-oral films before and after treatment show the advanced resorption of the second deciduous molar.

(Figure 7.11 continued)



(f)



(g)

have been superfluous, except in the most exceptional displacements.

MAXILLARY FIRST MOLARS

In the early mixed dentition, one may occasionally see the erupting maxillary molars become caught by the distal bulbosity of the adjacent deciduous second molar (Fig. 7.11). This is usually an early sign of crowding of the dentition, although it may simply be due to an abnormal mesial tilt of the first molar. Clinically, the essential diagnostic criterion is that the marginal ridges of the two adjacent teeth are at different levels, with that of the deciduous tooth being more occlusally placed. In the more severe cases, the mesial marginal ridge of the permanent molar is unseen, beneath the area of the distal CEJ of the deciduous tooth. At best, the distal cusps may be in occlusion with the mandibular molars, but usually the impaction prevents adequate eruption for this to occur. Occasionally, the permanent molar is completely prevented from erupting, and does not break through the mucosa.

A periapical or panoramic radiograph of the area will usually show most or all of the distal root of the deciduous second molar to have been resorbed and the general long axis and path of eruption of the permanent tooth to be tipped too far mesially (Fig. 7.11).

To leave a partially erupted molar tooth without treatment is to invite caries in the large stagnation area that has been created between it and the deciduous molar, which serves to compound the existing potential gingival/pulpal problem in the area of contact. In general, the mesial root of the deciduous second molar remains intact, to retain this tooth in its place.

If the deciduous second molar is shed prematurely or extracted, the permanent molar will move rapidly forwards, significantly closing off the space vacated by the lost tooth, within a few short months. The tooth also erupts occlusally at the same time, and its movement has a significant forward translation component, in addition to its mesial tipping component. This being so, orthodontic treatment, whose aim is to tip the tooth back to its ideal position after full eruption, will generate an excessive distal tip to the molar, which will leave the roots too far mesially. Secondly,

the achieved space will require to be maintained for around 5 years, until all the successional teeth have erupted. Regardless of how well designed and constructed the proposed space-maintaining device may be, its placement in a 7- or 8-year-old patient must provide some concern vis-à-vis its deleterious effect on the long-term prognosis of the first molar.

Many original ideas and gadgets have been suggested to disimpact the ectopic first molar from beneath the distal bulbosity of the deciduous second molar, the simplest of which has been to use an elastic separating ring or other form of orthodontic separator, which are normally used to create spaces prior to banding molars. These may be successful in some of the very mild cases, although what frequently happens is that a space between the teeth is produced within a week or so after placement of the ring. The elastic ring is then removed to allow the permanent tooth to erupt occlusally. In many cases, the molar tips right back into its previously impacted position, and nothing will have been achieved.

This type of relapse may occur with any method that is only concerned with tipping the tooth distally, without providing for a retention period. The retention period is intended to permit additional eruption of the tooth, while preventing reimpaction.

A fixed device has several apparent inherent advantages, but it must be remembered that the patient is a young child, who may be relatively unwilling to cooperate in its construction. Additionally, most orthodontists do not have a selection of preformed deciduous second molar bands, and the placement of a band on the permanent molar is impossible in all but the simplest of cases. Suitable conditions for composite bonding are also exceptionally difficult to attain in the molar area of such a young child, and results are unreliable.

Nevertheless, appliances have been designed based on a fixed band on the deciduous second molar only, or on an additional fixed band on the second deciduous molar of the opposite side, through the agency of a soldered palatal arch. A soldered spring is formed on a model, which fits into the most convenient and deepest occlusal pit of the

ectopic molar and is activated prior to cementation of the appliance (Proffit, 1992). It is quite difficult to readjust this spring in the mouth, which may make this a one-time-activation appliance, unless the whole cementation process is repeated.

At first glance, a removable appliance seems inappropriate, since there appears to be no way of passing a cantilever spring across the interproximal area, mesial to the tooth, to apply the necessary distal force. However, the removable appliance offers excellent ways of overcoming the drawbacks described above (Becker, 1977). Good retention is necessary, and this is best supplied by placing an Adams' clasp on the second deciduous molar of that side, on the erupted first permanent molar on the opposite side and on the two central incisors. Additionally, a three-quarter circumferential clasp placed on the first deciduous molar usually offers excellent retentive support (Fig. 7.11).

In more severe cases of this type, the resorption process will have completely eliminated the distal root of the deciduous molar, and, if careless probing is performed with a sharp explorer, perforation at the distal aspect of the deciduous molar is very likely to occur. Clinically, the sharp enamel edge at the cervical margin of the crown and the abrupt absence of continuity may be quite obvious, in the same way as is seen with any deciduous tooth immediately prior to its normal shedding. In this area, former pulpal tissue will have merged with the surrounding gingival tissue. Inflammation of this tissue at this juncture will therefore no longer give rise to a pulpitis, and it will repair symptomlessly, as with any other injured gingival tissue.

In the cases of this type with which we have had experience, there have been no adverse clinical symptoms related to the deciduous second molar tooth, nor has periapical radiolucency been evident on X-ray to suggest pulp death. Extraction has not been required, and the tooth has remained to act as a natural space maintainer until shedding has occurred at a much later stage, closer to the normal shedding time and late enough to find the second premolar erupting rapidly thereafter. This is preferable, from every point of

view, to extraction and replacement by an artificial space maintainer.

To find the parallel situation in the mandibular arch is very rare. However, management would be very similar to what has been described for the maxillary first molar.

MANDIBULAR SECOND MOLARS

Impaction of the mandibular second molar is uncommon, but, when it occurs, it is very similar in its appearance to that so frequently associated with third molars. Almost invariably, the impaction is due to a mesial inclination of the tooth, which brings it into contact with the distal side of the first molar, below its bulbosity and close to the cervical area. This, too, is probably a sign of a short arch length and retromolar crowding.

Unlike the maxillary first molar, the mesially impacted mandibular second molar is frequently unerupted, and usually comes to light in a routine dental examination, when it shows up on the bite-wing radiographs. However, this view cannot replace the periapical film, a lateral oblique extra-oral view or a panoramic scan, which will show details of the tooth, from crown to apex, and its relationship with the unerupted third molar. The tooth may also have a buccal or lingual tilt, which will generally be revealed by palpation, although an occlusal view will serve to confirm.

Local treatment

If treatment is to be performed on a local basis only, in the absence of any other form of concurrent malocclusion, then the first part of the treatment involves the surgical removal of the overlying mucosa, to expose the occlusal surface. As with the maxillary first molar that we have discussed above, a removable appliance may be used, with the same mechanical principles (Becker, 1977).

Alternative fixed-appliance methods abound, but their design is too frequently restricted to

just two or three teeth, which may seriously undermine the anchorage. Ideally, teeth on both sides of the mandibular dental arch should be included in the anchorage unit (Majourau and Norton, 1995), in order to prevent unwanted movement of other teeth in the arch, particularly to eliminate the possible occurrence of lower incisor crowding. A minimum suggested anchorage unit should include fixed bands on both first molars, joined by a soldered lingual arch, and orthodontic brackets on the premolars of the affected side.

The active element may be constructed in one of four ways:

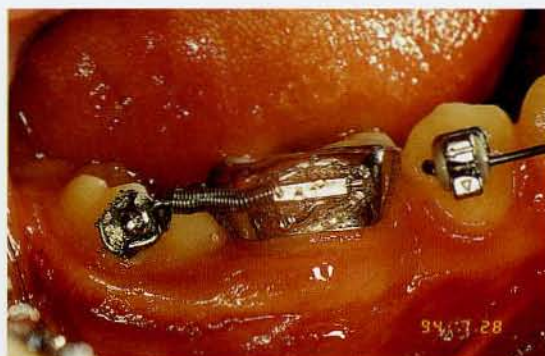
- A free-sliding sectional wire is slotted into the brackets and the molar tube on the affected side, activated by an elastic module, with its distal end latching on to a small attachment on the buccal or occlusal side of the impacted tooth.
- A similar method is used, employing a compressed coil spring (Fig. 7.12).
- A large and stiff open loop of rectangular wire is placed in the distal end of a buccal tube or wide Siamese bracket on the molar and designed to widely encircle the impacted tooth, with a small helix at its extremity. By tying a stainless steel ligature between a bonded eyelet or button on the occlusal of this tooth and the small terminal loop, distal pressure is brought to bear on the impacted molar (Majourau and Norton, 1995).
- A complete round wire loop with a distal helix may be slotted into buccal and lingual horizontal tubes on the molar band. Activation is made as for (c) by tying a steel ligature between the helix and an attachment on the tooth (Fig. 7.13).

Treatment as part of a comprehensive orthodontic treatment plan

For most cases, some form of overall malocclusion is present, for which treatment needs to be prescribed. The resolution of the impacted tooth should be integrated into the general treatment plan.



(a)



(b)



(c)



(d)

Figure 7.12

(a,b) A coil spring is threaded on to a sectional archwire, which is slotted into the distal end of a buccal tube on the first molar band. The distal end of the wire carries a welded stop or cross-piece, which permits compression of the coil spring against a button or eyelet attachment on the second molar. A lingual arch and fully bracketed appliance is present for additional anchorage. (c,d) Panoramic views before and after treatment.

If the overall malocclusion requires extraction, consideration should be given to the extraction of this impacted tooth, together with appropriate balancing and compensating extractions in the other quadrants of the mouth (Wilson, 1966; Staggers, 1990; Richardson and Richardson, 1993). This is not a frequent extraction of choice, but, under the circumstances of a very difficult impaction, it should be considered. This enables the dispersal of mild crowding to be effected with great facility, without the need for the extensive root uprighting movements that are seen with premolar extractions. However, the orthodontist will be counting on the favourable eruption of the third molars (which will be significantly earlier in these cases) and their spontaneous alignment. Should this not occur, a further period of treatment will need to be initiated in the young adult stage, aimed at uprighting the mesially tipped third molars, from a position that may be reminiscent of the initial position of the extracted second molar! In this situation, the above procedures may be applied to bring about third-molar uprighting, in exactly the same way as with second molars.

Perhaps the best way to visualize the potential influence of the extraction of different groups of teeth, is on the panoramic radiograph. With a mesially tipped second molar in an extraction case, the loss of a first or second premolar and the mesial movement of the first molar may often free the tooth to erupt, but the tipping will remain, and may even become worse, with the tooth appearing to 'fall flat on its face'. Uprighting will then need to be undertaken, using the existing multibracketed appliances.

Where the mandibular arch is well aligned or slightly crowded, mesial to the first molars, but there is a Class II relationship or crowding of the maxillary dentition, all the upper and the posterior lower teeth will probably need distal movement, rather than extraction. This will generally be performed with the use of an extra-oral headgear, to move the maxillary teeth distally and thus to provide the space necessary for the alignment of the maxillary teeth. If Class III

intermaxillary elastics, supported by the headgear, are used against a lower appliance, whose purpose is to move the mandibular molars distally, the force will be transferred through interproximal contacts to the second molars, which will initially resist the movement. However, if the second molar is tilted less than 45° and is in contact with the distal of the first molar crown, above the CEJ area, the tooth will ultimately tip distally and upright, while the first molar will itself be tipped distally. Once the second molars have erupted, the distalizing force is discontinued, and the first molar will then spontaneously tip forward until residual space has been closed off.

IMPACTION AND CROWN RESORPTION

In teeth that are unerupted over many years, the outer enamel epithelium may occasionally break down, and direct contact between bone and enamel occurs. In time, this may lead to resorption of the enamel, often with the laying down of bone in the resorption lacunae. Any tooth may be affected, although it tends to occur in adults whose dentition is established and where the unerupted tooth may have been replaced prosthetically. Rarely, it may occur in a young person, for whom there is a relatively greater importance in bringing the tooth into the dental arch. The first clue to its existence is seen radiographically, with difficulty in distinguishing the outline of the dental follicle on a radiograph. This usually signifies the initiation of a replacement resorption process of the enamel, with bone being laid down in the area. In its more advanced stages, the radiographic appearance of the tooth shows a loss of the sharp outline of the crown and, later still, a reduction in the radiopacity of the crown (Fig. 6.11), associated with a steady decalcification of the enamel (Blackwood, 1958; Azaz and Shteyer, 1978).

In order to move this tooth orthodontically, the entire crown area must be dissected free of the bone and a pack inserted to prevent the healing bone from again coming



(a)



(b)



(c)

Figure 7.13

(a) Button attachments bonded buccally and lingually to impacted second molar. (b) A wire loop carrying a distal helix is slotted into buccal and lingual tubes on the molar band. The wire loop is compressed by tying steel ligatures between the buttons and distal helix. (c) The final result.

into contact with the enamel surface. A pre-formed crown would be a better alternative, but access to the tooth is too compromised to allow its proper adaptation and cementation. At the same time, orthodontic force should be applied to the tooth and its activity maintained by frequent re-ligation.

INFRAOCCLUSION OF PERMANENT TEETH

Earlier in this chapter, we discussed infraoccluded deciduous teeth. In the permanent

dentition (Fig. 7.14), the same clinical picture is usually referred to as 'primary failure of eruption' (Proffit and Vig, 1981) or as 'secondary retention' (Raghoobar et al, 1992), and, in this condition, the teeth are sometimes completely covered and not visible intra-orally. This condition is due to ankylosis (Raghoobar et al, 1992), and the infraoccluded teeth do not respond to orthodontic force. It is generally believed that the teeth had originally erupted and subsequently become ankylosed, and their vertical development had stopped at that point. Some of the more severe cases may exhibit infraoccluded teeth that are situated so vertically distant from the



(a)



(b)



(c)

Figure 7.14

(a) A normal occlusion of the posterior teeth is present on the right side. (b) A severe lateral open bite has developed on the left side, due to primary failure of eruption. (c) The panoramic radiograph shows very marked infraocclusion of the left mandibular first molar and, to a lesser extent, also of the left maxillary second premolar and first molar.

occlusal plane that it is hard to imagine them ever having reached the oral cavity, particularly in the permanent dentition. With continued vertical growth of the adjacent teeth and alveolar bone, the ankylosed teeth become relatively lower and lower in the alveolus, until they become hidden by the gingival tissue and, sometimes, even by bone. Given that these teeth cannot be orthodontically moved, their 'absolute' anchorage potential may be exploited to orthodontically alter the position of neighbouring teeth (Fig. 7.15).

Proffit and Vig (1981) list the characteristics of primary failure of eruption as follows:

- (a) posterior teeth only, excluding incisors;
- (b) some erupt and then undergo submergence as in infraoccluded teeth, others are unerupted teeth with a large follicle;
- (c) deciduous and permanent teeth involved;
- (d) usually unilateral and asymmetric;
- (e) tendency for ankylosis, although not initially and no response to orthodontic forces;
- (f) orthodontic treatment leads to ankylosis;
- (g) no family history.

Their conclusion is that orthodontic treatment for these patients is not advised.

Contrary to the view of Proffit and Vig (1981), however, there may be a familial predilection (Raghoobar et al, 1992). Figure 7.16 shows panoramic radiographs of three children in one family, together with that of the father and the paternal grandmother, to show the differing expression of the phenomenon for each of these affected persons.

Orthodontic extrusive forces will have no effect on the infraoccluded teeth, and will tend to intrude the adjacent teeth towards the level of the infraoccluded teeth. By seizing the infraoccluded teeth with extraction forceps and applying minimal pressure, just sufficient to obtain a very minor degree of mobility of the teeth, one may effectively break the ankylotic junction. However, healing is rapid, and the ankylosis will soon become re-established. For this reason, orthodontic correction is not usually attempted.

Nevertheless, if a single central incisor tooth is affected in a young patient, the



(a)



(b)



(c)

Figure 7.15

(a) An infraoccluded left maxillary incisor. (b) A periapical radiograph of the tooth to show absence of lamina dura over much of the root surface. (c) Exploiting simple levelling and aligning archwires has also eliminated the deepened overbite, by drawing the other teeth to the ankylosed tooth. (Courtesy of Professor Y Zilberman.)

orthodontist may not be prepared to accept the 'no treatment' verdict. If the parents understand the poor prognosis, treatment may be attempted, provided that attendance for frequent activation is assured. Beyond the treatment of these isolated and accessible teeth, attempts to resolve the impaction of most other teeth whose roots have undergone ankylosis or external resorption are usually very disappointing.

Aside from naturally occurring ankylosis, there may be reason to suspect the possibility of an iatrogenic variety. In the past, it was

common to find an oral surgeon widely exposing the crown of the impacted tooth, down to the cemento-enamel junction and beyond, with consequent instrumentation of the root surface of the tooth. It may be that some of the blame for the relatively infrequent ankylosis of exposed impacted teeth is due to this type of unnecessarily aggressive surgical procedure.

External root resorption that has led to a merging of the periodontal and pupal tissues is a rare condition that may cause a non-ankylosed infraocclusion. Treatment requires



(a)



(b)



(c)



(d)



(e)

Figure 7.16

A family including (a) grandmother (b) father and (c-e) three siblings showing varying expression of primary failure of eruption.

surgical exposure of the resorption defect, its debridement and elimination with an amalgam filling. At the same time, root canal therapy must be initiated. After healing, the tooth may be aligned using conventional orthodontic methods (Fig. 7.17).

DENTIGEROUS CYST

Cysts of any source that arise in close proximity to teeth will displace those teeth ahead of the expanding cyst (Shafer et al, 1983). Professional intervention may influence the future of the displaced tooth, depending upon the type of treatment employed to resolve the cyst. The cyst may be opened and its lining completely shelled out, in a procedure called enucleation, with the surgical flap replaced to completely close off the exposed bone. The cavity that was formerly occupied by the cyst is now sealed off from the exterior once again. It will fill with blood clot, and healing is by primary intention. The unerupted tooth becomes deeply buried in the newly forming bone, and it will need to erupt through this repairing tissue. The prognosis for its eruption would appear to be in inverse proportion to its distance from the surface. Nevertheless, this approach is particularly suitable if the cyst is due to chronic periapical inflammation of the deciduous tooth, in which case it is termed a radicular cyst.

A dentigerous cyst arises from the outer enamel epithelium of the developing tooth, after crown development has been completed, and the crown of the tooth is located within the cyst. The line of treatment that is usually offered is referred to as marsupialization. This involves opening the cyst into the oral cavity at its most superficial point, and maintaining the patency of this orifice over a long period of time. The cut linings of the cyst and the oral mucosa fuse to become continuous with one another. In time, the lined cavity becomes smaller and smaller, as bony regeneration occurs, to fill in from the bottom up. As it does so, the tooth generally progresses, in the vanguard of the regeneration.

Spontaneous resolution of the impaction

may be expected to occur to a significant degree when the cyst is marsupialized, and several truly remarkable cases have been reported in the literature (Fearne and Lee, 1988; Sain et al, 1992). Treatment by enucleation will result in incomplete removal of the epithelium, around the neck of the tooth crown, or accidental dislodgement of the tooth during the curettage process.

It would be naive to suppose that all cases will be corrected so completely, without very considerable and extensive additional mechanotherapy. The crown of the tooth is fully exposed within the cystic cavity, and its surrounding periodontal attachment is very rudimentary and weak. In larger cysts, marsupialization will slowly allow the bone to regenerate and to repair the large defect that the cyst has created. The repair occurs slowly, and the tooth will be in the vanguard of this progress. Any attempt to apply orthodontic traction to the tooth at this time will extrude it ahead of the advancing bone, thereby weakening its bony and periodontal support and prejudicing its longevity.

It must be concluded that the cyst must be treated first and that it is then important to follow up the healing process until the bone has completed the reparative fill-in of the bony defect. Only at that point, which will be many months later, should an assessment be made of how much improvement has occurred naturally, how much more may be expected, and how much orthodontic treatment is needed to improve the positions of the teeth. It is unlikely that such treatment will make up for any residual bony defect, and, for this reason, patience is advised, in order to take advantage of the maximum natural potential for alveolar bone repair. There is therefore no value in bonding an attachment to the tooth at the time that the marsupialization is undertaken initially.

When enucleation, rather than marsupialization, of the cyst has been performed, the healing process will leave the affected tooth where it is – often grossly displaced from its proper place in the arch. Furthermore, with the lining of the cyst removed, the large bony defect will fill with blood clot, whose undisturbed reorganization will bring about heal-

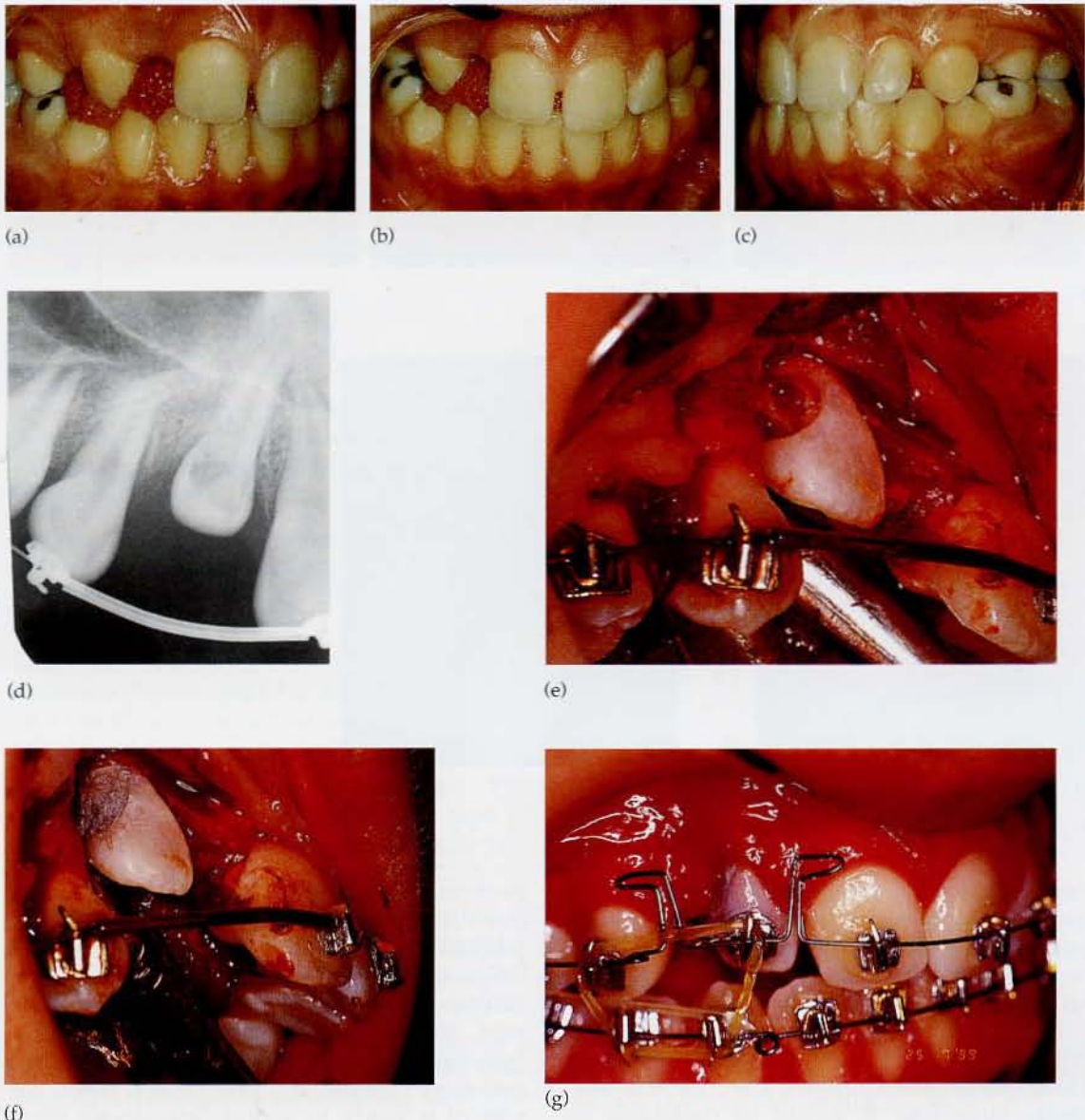


Figure 7.17

(a–c) Maxillary first premolars had been extracted by another practitioner ‘... to allow space for eruption of the unerupted right lateral incisor’. Note the relative lack of vertical development and tipping of adjacent teeth, reminiscent of an association with infraocclusion. (d) The pre-surgical periapical radiographic view. (e) Following orthodontic space regaining, surgical exposure reveals the cervical resorption defect. Soft resorption-replacement tissue had prevented the eruption. (f) The resorption area was debrided, and the exposed pulp extirpated and root-filled temporarily with calcium hydroxide. After amalgam restoration placement, an eyelet was bonded and immediate traction applied. (g) The final stages of eruption mechanics. (h–j) The completed orthodontic result, after definitive root canal therapy was completed and a porcelain crown placed. (k,l) The clinical and periapical radiographic views of the tooth.

(Figure 7.17 continued)

(Figure 7.17 continued)



(h)



(i)



(j)



(k)



(l)

ing, by primary intention. To achieve this goal, a complete and hermetic closure of the surgical flap will be attempted, to protect the wound from infection. The surgeon will prefer not to run the risk of introducing infection, which could track along a stainless steel ligature wire that is ligated to an attachment on the impacted tooth, when the wound is a relatively large one. It would be preferable to wait for healing to occur and then to re-expose the tooth on a much smaller and more localized scale. However, following this surgical procedure, spontaneous improvement after its position has improved may be slight, and a tooth, grossly displaced by such a cyst, may remain in an untenable position, following filling-in of the surrounding tissues.

From the point of view of the oral and maxillofacial surgeon, treatment of this cyst is a priority – often for no reason other than to

confirm the relatively innocent diagnosis. It must be remembered that, until a biopsy and pathological investigation are performed, the diagnosis is only tentative. While the more sinister alternative diagnoses are fortunately rare, the surgeon cannot take the chance involved in delaying the performance of the necessary diagnostic procedures until the patient is ready to accept orthodontic treatment. From the orthodontic point of view, the patient should be prepared for treatment, with an understanding of the demands of oral hygiene, the need to wear appliances and the need to expose the impacted teeth. These requirements may often be fulfilled quite quickly, but it is unfair to coerce patients into a hurried decision before they are ready, and it is usually counterproductive.

It would be logical to infer from this discussion that, although the orthodontist has much

to contribute to the outcome of the treatment, this contribution relates to the latter stages and not to the immediate prospects. It would therefore be wise to include the orthodontist in the decision-making team, but inappropriate for him or her to become involved in the early stages of treatment in any active manner, until much of the bony filling-in has occurred and the tooth has migrated down ahead of this.

REFERENCES

- Azaz B, Shteyer A (1978) Resorption of the crown in impacted maxillary canine. A clinical, radiographic and histologic study. *Int J Oral Surg* 7: 167-71.
- Becker A (1977) The correction of mesially angulated semi-impacted molar teeth by simple orthodontic means. *Isr J Dent Med* 26(2): 17-22.
- Becker A, Karnei-R'em RM (1992a) The effects of infraocclusion: part 1 - tilting of the adjacent teeth and space loss. *Am J Orthod* 102: 257-64.
- Becker A, Karnei-R'em RM (1992b) The effects of infraocclusion: part 2 - the type of movement of the adjacent teeth and their vertical development. *Am J Orthod* 102: 302-9.
- Becker A, Karnei-R'em RM, Steigman S (1992c) The effects of infraocclusion: part 3 - dental arch length and the midline. *Am J Orthod* 102: 427-33.
- Becker A, Shochat S (1982) Submergence of a deciduous tooth, its ramifications on the dentition and treatment of the resulting malocclusion. *Am J Orthod* 81: 240-4.
- Blackwood HJJ (1958) Resorption of enamel and dentine in the unerupted tooth. *Oral Surg Oral Med Oral Path* 11: 79-85.
- Brezniak N, ben-Yehuda A, Shapira Y (1993) Unusual mandibular canine transposition: a case report. *Am J Orthod Dentofac Orthop* 104: 91-4.
- Fearne J, Lee RT (1988) Favourable spontaneous eruption of severely displaced maxillary canines with associated follicular disturbance. *Br J Orthod* 15: 93-8.
- Kohavi D, Zilberman Y, Becker A (1984) Periodontal status following the alignment of buccally ectopic maxillary canine teeth. *Am J Orthod* 85: 78-82.
- Kurol J (1984) Infraocclusion of primary molars. An epidemiological, familial, longitudinal, clinical and histological study. *Swed Dent J* 21 (Suppl): 1-67.
- Kurol J, Thilander B (1984) Infraocclusion of primary molars and the effect on occlusal development, a longitudinal study. *Eur J Orthod* 6: 277-93.
- Majourau A, Norton LA (1995) Uprighting impacted second molars with segmented springs. *Am J Orthod Dentofac Orthop* 107: 235-8.
- Proffit WR (1992) *Contemporary Orthodontics*. Mosby Year Book, St. Louis.
- Proffit WR, Vig KWL (1981) Primary failure of eruption: a possible cause of posterior open bite. *Am J Orthod* 80: 173-90.
- Raghoobar, Jansen HW, Jongbloed WL, Boering G, Vissink A (1992) Secondary retention of permanent molars: an assessment of ankylosis by scanning electron and light microscopy. *Br J Oral Maxillofac Surg* 30: 50-5.
- Richardson ME, Richardson A (1993) Lower third molar development subsequent to second molar extraction. *Am J Orthod Dentofac Orthop* 104: 566-74.
- Sain DR, Hollis WA, Togrye AR (1992) Correction of superiorly displaced impacted canine due to a large dentigerous cyst. *Am J Orthod Dentofac Orthop* 102: 270-6.
- Shafer WG, Hine MK, Levy BM (1983) *A Textbook of Oral Pathology*, 4th edn. WB Saunders, Philadelphia.
- Staggers JA (1990) A comparison of results of second molar and first premolar extraction treatment. *Am J Orthod Dentofac Orthop* 98: 430-6.
- Wilson HE (1966) The extraction of second permanent molars as a therapeutic measure. *Trans Eur Orthod Soc* 42: 141-5.

8 IMPACTED TEETH IN THE ADULT PATIENT

CONTENTS • Neglect and disguise • Management • The need for temporary prostheses during treatment • Supplementary clinical concerns • Temporary prosthetic replacement and tooth transposition • The unerupted third molar as a potential bridge abutment • Implant anchorage

NEGLECT AND DISGUISE

A small but significant number of untreated impacted teeth will eventually find some way of erupting into the mouth – without treatment – although this may be many years after their normal eruption time, and then often into an ectopic eruption site. This is particularly true of maxillary canines (Thilander and Jacobson, 1968), and in direct contradiction of the popular view that eruption potential is lost when the root apex closes (Kokich and Mathews, 1993). Nevertheless, a good proportion will remain unerupted and asymptomatic for many years. Prosthetists are all aware of the occasional patient complaining of the eruption of a tooth under a denture, often many years after the patient had become otherwise edentulous.

For the most part, during the childhood of the particular adult patient concerned, advice was probably sought and rejected, with the reasons for this being very varied. The patient may have been an orthodontically unmanageable child at the appropriate age; perhaps the dentist or orthodontist was insufficiently convincing in the task of informing the parent of the consequences of non-treatment; or the

parents' level of dental awareness was inadequate, the idea that surgery would be needed was possibly abhorrent to the parents, or simply the cost and duration of the proposed treatment were unacceptable. Just occasionally, a surgical exposure procedure will have been carried out at the appropriate time, have failed to elicit eruption and was not then followed up. Some impacted teeth, particularly maxillary canines, may simply never have been diagnosed. One further possibility that is not unfamiliar is that a dentist succumbed to the pleadings of the parent to 'do something temporary to make-it-look-good', until they would be ready for the definitive treatment – a time that never arrived!

It may be difficult for the orthodontist to imagine the situation where a patient has reached adulthood with a central incisor still impacted. This will have been obvious from around the age of 7 years, but the patient only sought treatment in his/her twenties or, possibly, even later. This type of neglect is indeed unusual, and its prevalence seems likely to vary from country to country, in inverse proportion to the level of dental awareness in the population. A country that offers its citizens some form of national dental insurance may



(a)



(b)

Figure 8.1

Impacted right maxillary central incisor (a) replaced by poorly matched artificial tooth on 'flipper' (spoon) denture (b).

**Figure 8.2**

Impacted right maxillary central incisor. The right lateral incisor crown has been enlarged by a composite build-up.

be expected to have a lower prevalence among its adults, since one would hope that treatment would have been carried out at the appropriate time, given the relative freedom from financial constraints in a welfare state. Cost, however, is not the only factor and probably not even the dominant one.

Whatever the reason, however, the adult patient will usually present with the incisor anomaly unsuccessfully disguised in one of three ways.

- 1 A retained deciduous tooth may have been enlarged with the addition of composite material, although this will prob-

ably have improved only its length. Any increase in its width will be limited by the reduced mesio-distal space available to the tooth, the result of the marked mesial tipping of the adjacent lateral incisor and the central incisor of the opposite side.

- 2 This reduced space may have been maintained with a 'flipper' (spoon) partial denture, carrying a single and poorly matched small tooth (Fig. 8.1).
- 3 The lateral incisor may have been enlarged, with the use of composite material in an attempt to simulate the shape of the impacted central incisor (Fig. 8.2).

There are serious drawbacks with each of these treatment alternatives, which focus principally on the very poor appearance of the results. The absence or reduction in size of a central incisor is always obvious, as too is any significant shift in a maxillary dental midline, even to the casual observer. The tipping of the two teeth adjacent to the impacted incisor is too severe to escape notice, and the angle of the lateral incisor is too acute for its long axis to be visually 'realigned' by composite additions or by reshaping. The narrowness of the neck of the tooth makes an aesthetically convincing reconstruction as a central incisor impossible.

MANAGEMENT

It is quite clear that, under these circumstances, the first and most important prerequisite to any form of treatment for the missing tooth is to provide the maxillary dental arch with an ideal shape in each of the three planes of space. In practical terms, this means the following.

- 1 *Levelling and aligning the entire dental arch.* All ectopically placed teeth will need to be brought into an ideal archform, teeth will need to be aligned in a single, uniform occlusal plane and all rotations dealt with.
- 2 *Reopening a space of suitable mesio-distal width in order to accommodate the impacted tooth in the arch.* Correcting the palatal inclination of the canine and tipping the lateral incisor of the same side and the central and lateral incisor of the opposite side will usually provide adequate space, although distal movement, extraction or interproximal enamel stripping may need to be considered.
- 3 *Correcting the dental midline to be continuous with the lower and with the midline of the face.* This is normally achieved as a result of the reopening of space, but it may require the use of coil springs or anterior, oblique, intermaxillary elastics as part of

a more comprehensive orthodontic appliance programme.

- 4 *Closing down an anterior open bite and bringing the teeth into occlusion.* This is probably best achieved by properly aligning the molar tubes and by altering bracket height on the anterior teeth, thereby bringing about the desired extrusion of the teeth. However, anterior vertical elastics are of material help in this situation.

Once these aims have been achieved, the patient is ready for that stage in treatment when all resources will need to be concentrated on the impacted tooth. The entire dental arch must be consolidated into a compound and united anchorage unit, to which the unerupted tooth will be drawn.

In Chapters 6 and 7, we mentioned that teeth that have been impacted for many years sometimes undergo pathological change that prevents their eruption (Azaz and Shteyer, 1978), even when all other factors are favourable. It is by no means always possible to diagnose pathological change from a radiograph, unless there is a loss of the follicular sac and actual enamel resorption has become evident over wide areas of the surface of the unerupted tooth. It is therefore true to say that, whenever an adult patient presents for the treatment of an impacted tooth, a calculated risk is taken in offering this kind of treatment to resolve the impaction.

In the most adverse of circumstances, the central incisor tooth will have to be extracted and perhaps surgically reimplanted. In that event, the preparation of the dental arch described above will have provided optimal clinical conditions to accept the implant or other form of artificial restoration of the space. An ideal pontic width is present, all other teeth are aligned and the occlusion is good. However, the surgical removal of a grossly displaced impacted tooth, high above its normal position, will leave a considerable and unsightly bony defect. This will be difficult to conceal in the gingival area around a fixed prosthesis, and will not lend itself to the placing of an implant without suitable and prior osseous ridge reconstruction

(Sailer, 1989; Richardson and Cawood, 1991; Simion et al, 1992; Lustmann and Lewinstein, 1995).

The patient must be brought into the decision-making process from the outset and should be informed of the potential advantages of each of the stages of the treatment. Prognosis for the success of the pre-surgical stages of the treatment is excellent, but it is not so certain for the alignment of the impacted tooth. Offering the treatment plan to the patient is therefore probably best accomplished if it is based on explaining the benefits of the limited objectives, i.e. aligning the teeth for the purposes of achieving improved conditions for the construction of a conventional prosthodontic or implant-borne replacement. The added bonus that will be derived from success in the resolution of the impaction may then be properly brought into perspective to provide the desirable added incentive.

By whatever means the value of the treatment is explained, care should be taken to fully inform the patient that the possibility of failure to bring the impacted tooth into the arch is real, but that contingency plans are available in this disappointing eventuality.

THE NEED FOR TEMPORARY PROSTHESES DURING TREATMENT

For the adult patient, planned orthodontic space-opening for an unerupted anterior tooth is a daunting prospect. All central and lateral incisors and many maxillary canines require some form of immediate temporary prosthetic replacement until such time as the permanent tooth comes into its place. With some patients, particularly those more concerned with their appearance, or those who have a broader smile or a wider dental display that is evident in facial expression and social intercourse, there may be a need to artificially replace even premolar teeth.

If the artificial restoration takes the form of a removable plate carrying a single tooth, a 'flipper' (spoon) denture, the patient may have considerable difficulty becoming accus-

tomed to it, even if its retention is initially adequate. Of greater concern, however, is the fact that the adjacent teeth and many others need to be moved during the orthodontic treatment, which will rapidly make this artificial denture ill-fitting. Furthermore, its adaptation to the contour of the other teeth in the jaw may actually interfere with the planned orthodontic movement.

For this type of artificial replacement to be successful, Adams' clasps may have to be used on the second molars, or, alternatively, a modified circumferential clasp may hook over the buccal tubes of the first molars. These teeth are often excluded from the planned dental movements, and may sometimes be helpful in retaining such a plate, although the distance between the clasps and an incisor pontic may be the cause of an unacceptable degree of instability.

Clearly, more satisfactory alternative methods of artificial replacement are essential to the successful pursuit of treatment for the adult patient, and these must provide an answer to the several shortcomings of the 'flipper' denture. Indeed, given a little thought in their design and rather than their playing the role of the villain of the piece, assistance may be derived from the method of artificial replacement, which may contribute to the operation of the active orthodontic appliance.

The active removable plate

If a removable plate is to be worn to hold the artificial tooth in place, it makes good sense to augment that plate with active elements that will also produce tooth movement. Looked at in a different way, this means the designing of a simple removable orthodontic appliance, carrying springs of one sort or another that are aimed at realigning the teeth to reopen the anterior space and, at the same time, to fill that space with an artificial tooth.

This method has some important advantages. The active plate is straightforward and easy to use, requiring very limited expertise

in its adjustment of the forces applied and in their direction. The artificial tooth may be easily altered in size as space-opening occurs, to maintain appearance.

However, the active removable appliance is unable of producing more than tipping movements of the adjacent teeth. Methods have been described where a removable appliance has been used to produce the extrusive movements needed to resolve the impaction of teeth (Fournier et al, 1982; Orton et al, 1995). Its effectiveness in this capacity is limited, and it cannot be expected to perform labio-lingual or mesio-distal root movements or rotatory movements that are often needed to fully align these aberrant teeth. Therefore in cases where removable appliances are used to resolve the initial impaction and to erupt the tooth, they must be followed by a fixed appliance to bring about the successful completion of a second phase of the treatment, which is aimed at the fine positioning of the teeth in all three planes of space.

The soldered palatal arch

In the adult patient, the scope of orthodontic correction that is planned tends to be more localized and less comprehensive, particularly when a single and grossly displaced tooth is present. Accordingly, the first maxillary molar teeth are most commonly used as anchor teeth for the fixed appliance, and their orthodontic movement is not usually required. This being so, the buccal aspects of these teeth and buccal/labial aspects of the teeth more anteriorly placed will be used to carry the orthodontic brackets, archwires and auxiliary. This leaves the palatal side of the teeth and the palate area free and available to serve the interests of the patient's appearance.

The missing central incisor

A soldered palatal arch, based on the molar bands, can provide an orthodontic appliance with an excellent anchorage base, at the same

time as acting as the vehicle for a satisfactory prosthetic replacement. Several approaches are available, and they depend on the adaptation of well-fitting preformed orthodontic bands to the molar teeth and their accurate transference to a plaster working model of the jaw.

On the working model, a palatal arch is fabricated and soldered on the palatal side of the molar bands. A small wire extension may then be soldered or bent into the anterior portion of the palatal arch, extending towards the space in the arch and terminating immediately palatal to the position of the missing tooth, with a configuration that will mechanically retain an artificial acrylic tooth. The exact location of the artificial tooth should be decided in accordance with the projected treatment goals of the case and not necessarily in line with the adjacent natural teeth. Thus, if an overjet is to be closed or a cross-bite treated, the siting of the artificial tooth should be made according to the intended final, post-treatment, position of the adjacent teeth. An occluded plaster cast of the opposite jaw is therefore necessary to assist in its accurate placement.

This is the simplest approach of this type and it offers the patient a good artificial replacement, which is well tolerated (Figs 8.3a,b). It also allows the adjacent teeth to be aligned without hindrance, while actually enhancing the anchorage value of the molars during retraction of a procumbent labial segment. The anchor molars cannot be rotated or tipped easily when using horizontal, intra-maxillary, elastics, owing to the stabilizing effect of the rigid soldered palatal arch.

A significant and valuable refinement of this approach involves bonding a conventional bracket to the artificial tooth, as with the other teeth. This makes the artificial tooth aesthetically compromised to a similar degree as the other teeth and therefore less recognizable as other than a part of the natural dentition. Since this tooth is rigidly attached to the molar teeth and at a fixed distance from them, this method has much more to offer. Its integration into the appliance system makes alignment and levelling more accurate and more rapid. Additionally, the need for elastic



(a)



(b)

Figure 8.3

(a) Same patient as in Fig. 8.2, to show initial stages of alignment and space opening. The composite build-up of the maxillary right lateral incisor is still in place. (b) Space has been reopened, the composite build-up of the lateral incisor has been removed, and the artificial central incisor is in place, attached to the soldered palatal arch.

traction to reduce the overjet will be eliminated, since the use of the initial fine-gauge and ideal archforms in the early weeks of treatment will perform this without any further modification. The distance and relationship between molars and the artificial incisor is fixed to the ideal length and position by the palatal arch. Thus a progression of ideal wire archforms will align all other teeth within that arch. Essentially, by linking the archwire to the fixed pontic, in its normal overjet and overbite location, the first stage of mechanotherapy, which generally deals with initial levelling and alignment only, now comes to

include automatic overjet and overbite reduction.

The overall length of the heavy palatal arch provides it with a degree of elasticity, despite its heavy gauge. Thus, while carrying a temporary prosthetic replacement, it may be used to widen or constrict the dental arch. In the present context, however, it has one other possible function, which is less obvious, but most helpful. The palatal arch has the potential to provide the vertical component of force that is needed to close an anterior open bite and subsequently the vertical traction needed to resolve the incisor impaction (Fig. 8.4).



(a)



(b)



(c)



(d)

Figure 8.4

Closing the anterior open bite, in the same patient as in Fig. 8.2. (a) The soldered arch has been deflected slightly vertically downwards to elongate the artificial tooth. (b) Placement of the archwire shows the degree of vertical displacement. The artificial tooth is now fully engaged in the archwire. (c) The extrusive force of the palatal archwire closes off the open bite. (d) The periapical view shows the impacted tooth to be dilacerated. The palatal arch is clearly seen, with the forward-pointing loop used to carry the radiolucent artificial tooth. An orthodontic bracket is also attached to this radiologically invisible tooth. (e) pre-treatment tangential radiograph. (f) Bonding of an eyelet to the anatomically palatal aspect of the incisor crown. (g) The elastic chain is gently raised and ensnared in the pigtail to provide immediate and controlled vertical traction. (h) Post-surgical periapical view to show the bonded eyelet and pigtails ligature. (i) The tangential view post-surgery, showing the length of the unseen part of the ligature and the relative heights of the tooth, the ligature extremity and the occlusal plane. (j) The impacted tooth has erupted 5 months later; note the reduction of the cervical portion of the artificial tooth to allow for further progress. Traction was made to a newly placed labial attachment at this juncture. (k) Periapical view of the dilacerate incisor at the completion of treatment. (l) The orthodontic result: note the gingival appearance of the treated and untreated maxillary central incisors.

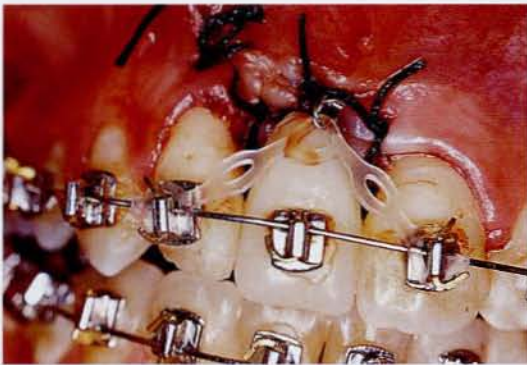
(Figure 8.4 continued)



(e)



(f)



(g)



(h)



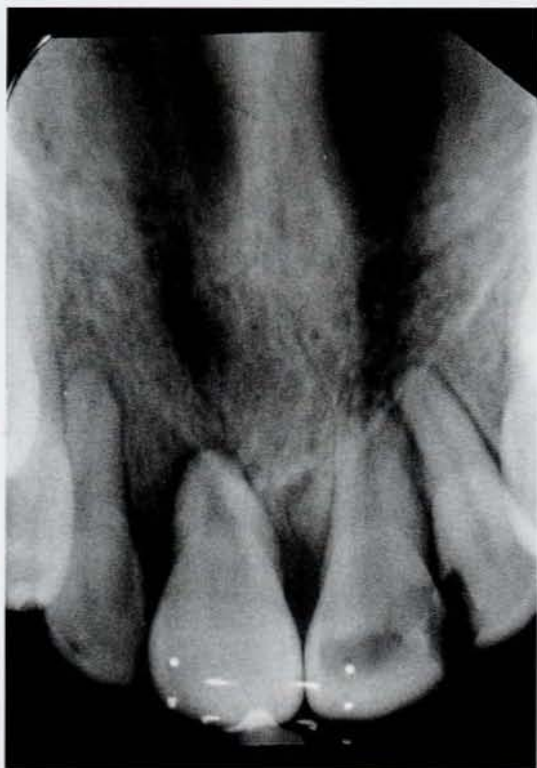
(i)



(j)

(Figure 8.4 continued)

(Figure 8.4 continued)



(k)



(l)

The missing maxillary canine

Aside from third molars and in common with the younger patient, the tooth most frequently found to be impacted in the adult is the maxillary canine. The principles of diagnosis, treatment planning and appliance therapy in the adult are no different from those of the child, although certain demands are made by the adult patient, which may make treatment methods less routine and more individualized. However, the duration of such treatment in the over-25-year-old age group is likely to be significantly longer than for the child patient (Harzer et al, 1994).

In a case with impacted incisor teeth, the

presence of a palatal arch does not encroach on the area where surgical exposure and post-surgical swelling are likely to occur, provided that the anterior portion of the palatal arch is not brought too far forward. A 'cut-back' design is usually most appropriate. In order to expose a palatally displaced maxillary canine, a wide area of palatal mucosa may need to be reflected back, and this, together with the possible sequel of even a minimal degree of post-surgical oedema, effectively disqualifies the use of a rigid palatal arch in these circumstances.

A trans-palatal bar, such as a Goshgarian or a simple 'across-the-palate' soldered arch, are usually sufficiently distant from the surgical

site to be used in these circumstances. They cannot be used for prosthetic replacement, and their only function is to enhance the anchorage. However, in combination with a buccal arm, they may be very useful and have definite indications.

In the case illustrated in Fig. 8.5, the adapted molar bands are transferred to a plaster working model and a transpalatal arch is soldered to the palatal side of the bands. Molar tubes are welded to the buccal side of the bands, and, gingival to these tubes, a heavy buccal arm is soldered, extending vertically upwards into the sulcus. The arm is then fabricated to follow the depth of the sulcus anteriorly until it reaches the canine area, where it again dips inferiorly, to terminate in a loop in the canine site. An artificial acrylic tooth is cured into this retention loop, in the place of the missing permanent canine.

Immediately after extraction of the natural deciduous tooth, the unit, which comprises two molar bands, a palatal arch and a buccal arm, is cemented into place, followed by appropriate orthodontic attachments on the other teeth. After initial alignment and space opening, the impacted canine is exposed surgically, from the buccal or palatal side, as appropriate to the case. Traction may then be applied in the normal way, but carried out behind the facade of the buccally retained artificial tooth.

As with the placement of a bracket on the artificial central incisor, described above, it is advantageous to design the integration of these prosthetic expedients into the orthodontic appliance system in such a way that they may contribute materially to the efficiency of the appliance. Thus, after cementation of the bands carrying these additions, the buccal arm is displaced further buccally, so that its passive position is a few millimetres buccal to its original location. If it is now tied directly to the impacted canine, using a steel ligature, this will realign the displaced buccal arm and artificial tooth. The energy stored by this long and elastic buccal arm will now provide the traction needed to draw the impacted tooth towards its place in the arch.

SUPPLEMENTARY CLINICAL CONCERNS

The basic premise for the use of these palatal and buccal arches has been that the first molar tooth does not require to be orthodontically moved. Needless to say, there are cases in which movement of the first molars is an essential part of the orthodontic strategy of the treatment of a particular adult. These may include cases where there is a pronounced rotation or a palatal or buccal displacement of this tooth, but they may also include the premolar extraction cases where closure of excess space from the distal will be needed.

In these cases, several options are still available to allow the smooth pursuit of orthodontic treatment. In the first place, a single buccally or palatally displaced molar tooth, which it is planned to use as an anchor unit, may be tipped into its place using a removable appliance. This appliance will need to carry some form of buccal or palatal spring, which will be used to move the tooth in the appropriate direction, suitable clasps to retain the appliance firmly in position, and, possibly, an artificial tooth to replace the impacted incisor tooth in the interim. Alternatively, an existing 'flipper' denture may be augmented to incorporate the same clasp and spring elements.

When more extensive movement of the anchor teeth is required, this is usually enacted in a preparatory orthodontic treatment phase, which is aimed at producing good alignment by uprighting, rotating and torquing the teeth, while limiting the appliance work and movement of the anterior teeth to levelling and aligning. During this procedure, it is important to enable the patient who has been wearing an artificial denture to continue to do so until such time as the alignment stage is complete. Similarly, an over-retained deciduous incisor tooth should be allowed to remain until the planned temporary prosthetic rehabilitation becomes practical. With the satisfactory completion of the preparatory orthodontic treatment phase and the teeth having been brought into good alignment, the precise



(a)



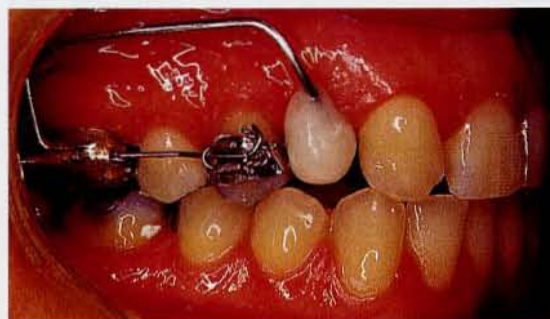
(b)



(c)



(d)



(e)



(f)

Figure 8.5

(a–c) A 47-year-old female has a maxillary left canine that is impacted adjacent to a peg-shaped lateral incisor. The erupted right canine is in the place of the congenitally absent lateral incisor. (d) The patient wears a removable partial plate to fill the canine sites on each side. (e–g) The molar bands are interconnected by a soldered 'across-the-palatal' heavy arch (not seen). A high buccal arm is soldered on each molar band, carrying an artificial canine tooth, to replace the discarded partial plate. (h) A small hook is cured into the left artificial canine, and the buccal arm is deflected buccally and inferiorly at the time of surgical exposure of the impacted canine. (i) Ligating the impacted tooth to the artificial tooth applies extrusive and buccal traction. (j–l) The left canine has been brought into its place, and a fixed partial prosthesis fills the gap on the right side.

(Figure 8.5 continued)

(Figure 8.5 continued)



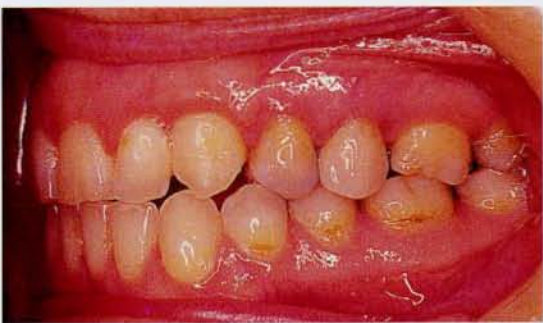
(g)



(h)



(i)



(j)



(k)



(l)

reopening of the space for the missing tooth is undertaken.

At this point, the palatal arch is constructed on a plaster model, into which the molar bands have been accurately seated and the artificial tooth sited, as described above. The patient's denture is now discarded or the over-retained deciduous tooth is extracted, and the palatal arch carrying the artificial incisor tooth is inserted by recementing the molar bands to their former place.

When moving teeth mesio-distally along an archwire with a multibracketed fixed appliance, the establishment of interproximal contacts between the teeth enables a high degree of control of individual tooth position. Once this has been achieved, uprighting and torqueing movements may be carried out, with care being taken to see that the spaces do not reopen. The desired treatment result includes closed contacts.

In the situation where a tooth is unerupted and space must be made for it, the orthodontist should err on the side of reopening excess space and then maintaining it until the tooth reaches its place. However, to do so, the space needs to be maintained during the many further months of treatment, when the adjacent teeth will be altering their relationships to one another. While attention is diverted to the details of the treatment in these other areas, changes may inadvertently alter the space. The original coil spring, which may have opened the space, must be de-activated, since it will otherwise continue to increase the dimensions of the space. However, the placement of active root-uprighting springs will tend to close the space by compressing the spring.

The size of the artificial incisor tooth and its mesio-distal siting may be very useful in holding the achieved space and in ideally placing the adjacent teeth, regardless of their locations and without the need for the coil spring or the ligation of groups of teeth. The natural teeth are swiftly brought into interproximal contacts with the artificial tooth and with each other, and this status is then simple to maintain.

TEMPORARY PROSTHETIC REPLACEMENT AND TOOTH TRANSPOSITION

Rarely, one or more of the impacted teeth is also transposed. For the most part, it is preferable to align the teeth in their transposed positions, rather than to try to retranspose them to their ideal positions, for reasons already discussed in Chapter 6. Nevertheless, there are situations in which this may be the preferred line of treatment.

Given the high frequency of missing lateral incisors in cases of transposition of maxillary canine/first premolar transposition (Peck et al, 1993), treatment of the transposition may have to consider the artificial replacement of the missing teeth during the appliance therapy. The use of a palatal arch to augment the anchorage value of the molar teeth and to provide the vehicle for the artificial replacement teeth is an effective way to deal with this problem (Fig. 8.6).

By tying in a labial archwire from molar to molar, passing through a bracket on each of the artificial lateral incisors, these strategic points on the perimeter of the arch are defined in relation to one another, since the incisor pontics are also rigidly fixed to the molar bands on the lingual side. The small section of labial archwire that intervenes between molar tube and incisor bracket is therefore well supported in terms of anchorage, and may be used to slide the more buccal of the transposed teeth (usually the canine) in the mesio-distal plane. At the same time, the more lingual of the transposed teeth must be moved further lingually to allow its partner to pass by. Finally, it must be moved in the opposite mesio-distal direction and back in the line of the arch.

To achieve this, the more lingual tooth may be ligated to several different and strategically planned loops and cross-pieces, which will have been prepared on the palatal arch ahead of time, using elastic thread. Once again, positive use is made of the palatal arch as an integral part of the orthodontic appliance system, and it is not merely a means of supporting an artificial tooth.



(a)



(b)



(c)



(d)



(e)



(f)

Figure 8.6

(a-c) A 27-year-old female with congenitally absent maxillary lateral incisors and maxillary canine/first premolar bilateral transposition. The deciduous canines and right lateral incisor are still present. (d) Occlusal view of maxillary arch. (e-g) Intra-oral views after extraction of deciduous teeth. (h-j) Treatment progress, seen from the right side. (k,l) Use of palatal arch as support for lateral incisor pontics and also to move premolars through varying use of elastic thread. (m) Occlusal view of complete maxillary dentition, with wire splint from first premolar to first premolar, including lateral incisor pontics. (n-p) Intra-oral views of the completed orthodontic result. The patient was referred for permanent prosthodontic treatment of the lateral incisor problem.

(Figure 8.6 continued)



(g)



(h)



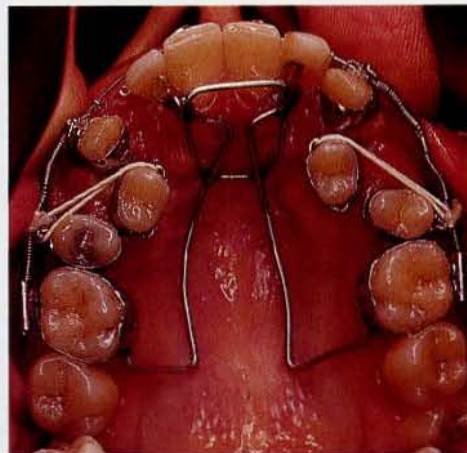
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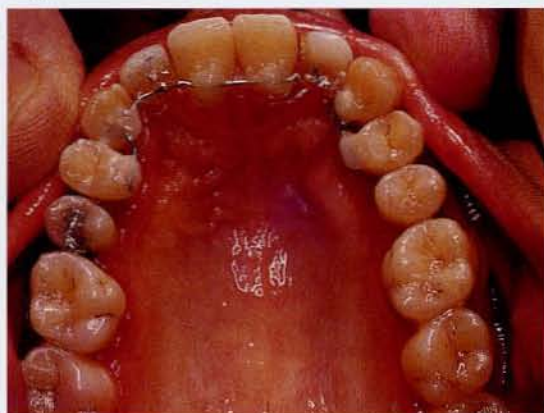


(k)



(l)

(Figure 8.6 continued)



(m)



(n)



(o)



(p)

THE UNERUPTED THIRD MOLAR AS A POTENTIAL BRIDGE ABUTMENT OR AS AN ANTAGONIST FOR AN UNOPPOSED TOOTH

In the previous chapter, we discussed the uprighting of molar teeth that were prevented from erupting, partially or fully, by their relationship with an immediate mesial neighbour. It is pertinent in the context of the present chapter to discuss a different scenario that commonly presents.

Following the extraction of posterior teeth in the adult patient, the establishment of a 'free-end edentulous saddle' makes oral rehabilitation problematic. This may sometimes find a potentially convenient solution in the discovery of an unerupted third molar. However, the absence of standing posterior teeth creates mechanotherapeutic difficulties

in providing the vertical traction that is aimed at enhancing the eruptive potential of an unerupted third molar.

Elastic traction of the tooth to the opposing jaw is a useful method, and has been referred to above (Orton et al, 1995), but the use of removable appliances in the adult patient is unreliable. Adults have far greater difficulty becoming accustomed to the bulk of the removable plate and its interference with masticatory and articular function. The use of a fixed mandibular appliance offers a much more satisfactory and dimensionally modest alternative, which interferes neither with eating nor with speech. Furthermore, if the mandibular appliance is to be used only as a source of anchorage, brackets and archwires may be dispensed with, making it very inconspicuous indeed.

An unopposed second molar in the opposite arch is the tooth that faces the potential



Figure 8.7

(a) A 54-year-old male patient, showing unopposed mandibular right second molar. (b) Close-up views of buccally displaced and partially erupted third molar. (c) A 0.024" round wire has been adapted to buccal surfaces of the premolar and molar teeth on the mandibular model. Note the retention loops and welded mesh pads. The distal extremity is in the shape of a hook, which has been covered with solder for patient comfort. (d) The L-shaped elastic configuration for ease of placement and wide range of action. (e) Following eruption, a partially bonded appliance is used to upright the third molar. Additional anchorage is derived from a soldered palatal arch from first molar to first molar. (f) The final stage of treatment.



(a)



(b)



(c)



(d)



(e)



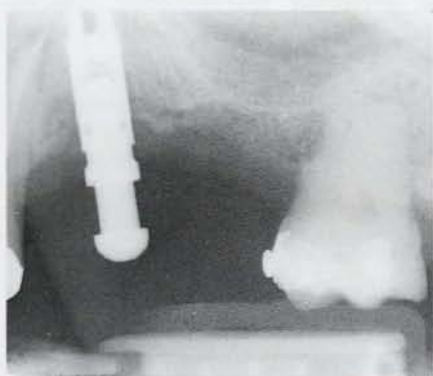
(f)

Figure 8.8

(a,b) An osseointegrated implant has been placed in the maxillary left second premolar site. A partially erupted and distally tipped third molar shows only its mesial surface and mesial occlusal cusps. (c) An elastomeric chain module applies force to the implant post, via the bonded eyelet on the molar. (d) Vertical force is applied to a mandibular bonded buccal bar, to achieve occlusal contact. (e) Fully occluding third molar. Note the use of three button attachments to provide vertical force with buccal or lingual vectors, as needed. The mesial button is to prevent the elastic from impinging on the gingiva. (f, g) Pre- and post-treatment radiographs. (h) Lateral view of the prosthodontic reconstruction.

(Figure 8.8 continued)

(Figure 8.8 continued)



(g)



(h)

eruption site and proposed final position of the unerupted tooth, while premolars may be occluding further forward. Vertical extrusion of teeth requires relatively low force values; nevertheless, it is important to include several teeth in the anchor unit and to rigidly link them together, to prevent or limit their reactive extrusion.

Using a plaster model of the patient's opposing jaw, a length of 0.024" (0.6 mm) stainless steel wire is adapted to the general form of the buccal surfaces of the teeth, from second molar to the first or second premolar (Fig. 8.7). The wire extends very slightly mesially to the first premolar and a few millimeters distally to the second molar, where it is bent into a hook. Those parts of the wire immediately overlying the tooth surfaces should also include small retention loops, to which should be welded small patches of stainless steel mesh. These mesh pads are adapted to the shape of the tooth surface.

Returning to the patient, the buccal surfaces of the teeth are etched and the wire bonded to them, using a composite material. Unfilled resin, such as Poly-C or Directon (TP Laboratories), is probably the easiest to use, is adequate for the task, and is easy to remove at the conclusion of the treatment. A small custom-made hook or button is prepared and bonded to the unerupted tooth, following its exposure. At the same visit as these proce-

dures are performed, the patient is taught to place a small latex elastic (3/8" medium or 5/16" light gauge) on the hook and to draw it round the wire extension distally to the opposing second molar and then forward to engage the small protrusion of the wire mesial to the first premolar.

This forms an L-shaped configuration to the elastic, which has a dual purpose. The overall length provides for a light force of excellent range, while, at the same time, making the manipulation of the elastic very easy for the patient. The vertical traction that is applied to the tooth may be altered to include a horizontal component, by altering the position of the distal end of the bonded wire, thereby also directing the tooth mesially, distally, lingually or buccally.

IMPLANT ANCHORAGE

A successful implant can be used to provide 'absolute' anchorage, since it forms an osseointegrated union with the bone, and, like an ankylosed tooth, will not respond to orthodontic forces (Fig. 8.8). The use of implants in this manner would appear to offer considerable promise for the future, particularly for partially dentate adults, and for replacing extra-oral anchorage in non-growing patients (Roberts et al, 1984).

REFERENCES

- Azaz B, Shteyer A (1978) Resorption of the crown in impacted maxillary canine. A clinical, radiographic and histologic study. *Int J Oral Surg* 7: 167-71.
- Fournier A, Turcotte J, Bernard C (1982) Orthodontic considerations in the treatment of maxillary impacted canines. *Am J Orthod* 81: 236-9.
- Harzer W, Seifert D, Mahdi Y (1994) Die kieferorthopadische einordnung retinierter eckzahne unter besonderer berucksichtigung des behandlungsalters, der angulation und der dynamischen okklusion. *Fortschr Kieferorthop* 55: 47-53.
- Kokich VG, Mathews DP (1993) Surgical and orthodontic management of impacted teeth. *Dent Clin N Am* 37: 181-204.
- Lustmann J, Lewinstein I (1995) Interpositional bone grafting technique to widen narrow maxillary ridge. *Int J Oral Maxillofac Implants* 10: 568-77.
- Orton HS, Garvey MT, Pearson MH (1995) Extrusion of the ectopic maxillary canine using a lower removable appliance. *Am J Orthod* 107: 349-59.
- Peck L, Peck S, Attia Y (1993) Maxillary canine-first premolar transposition, associated dental anomalies and genetic basis. *Angle Orthod* 63: 99-109.
- Richardson D, Cawood JI (1991) Anterior maxillary osteoplasty to broaden the narrow maxillary ridge. *Int J Oral Maxillofac Surg* 20: 342-8.
- Roberts WE, Smith RK, Zilberman Y et al (1984) Osseous adaptation to continuous loading of rigid endosseous implants. *Am J Orthod* 86: 95-111.
- Sailer HF (1989) Two new methods combining osteotomies and endosseous titanium screw implants for the narrow maxillary ridge and the atrophic lateral mandible. In: *Proceedings of Third International Congress on Preprosthetic Surgery, 'The edentulous jaw', Arnhem, The Netherlands, 1989*, 62-3 (abst).
- Simion M, Baldoni M, Zaffe D (1992) Jawbone enlargement using immediate implant placement associated with a split-crest technique and guided tissue regeneration. *Int J Periodont Restor Dent* 12: 463-73.
- Thilander B, Jacobson SO (1968) Local factors in impaction of maxillary canines. *Acta Odont Scand* 26: 145-68.

9 CLEIDOCRANIAL DYSPLASIA

- CONTENTS** • Clinical features and dental characteristics • Treatment modalities
• Dental crowding • Retention • The relative merits of the different approaches
• Methodology of the Jerusalem approach • Treatment experience • Patient variation

CLINICAL FEATURES AND DENTAL CHARACTERISTICS

The cleidocranial dysplasia patient is typically of short stature, with a brachycephalic skull and bossing of the parietal and frontal bones. There is hypoplasia of the midface, giving the misleading appearance of mandibular prognathism. The skull sutures and fontanelles exhibit delayed closure and secondary centres of ossification occur in these areas, with the formation of wormian bones. The development of the clavicles is defective, and ranges from a small medial gap to total absence in severe cases (Kalliala and Taskinen, 1962; Bixler, 1976; Cohen, 1976; Zegarelli et al, 1978; Shafer et al, 1983; Tachdjian, 1990; Gorlin et al, 1990). The patient usually has a narrow chest and sloping shoulders. According to Stewart and Prescott (1976), more than 100 other anomalies have been associated with these major clinical features in the condition.

The palate is narrow and occasionally high, and there is normal eruption and number of the deciduous teeth. The permanent molars usually erupt late, but spontaneously, while the remainder of the permanent dentition, i.e.

the successional teeth, exhibits very delayed or non-eruption. Additionally, supernumerary teeth develop in the successional teeth areas in numbers that typically vary from none to around 12 in general, although the highest recorded number ever found was 63 (Yamamoto et al, 1989). Apart from barrel-shaped teeth and the rare occurrence of peg-shaped teeth in the maxillary incisor area only, the supernumerary teeth take the form of premolars in the premolar area, canines in the canine area and incisors in the incisor area. They may therefore be more appropriately referred to as supplemental teeth.

Cleidocranial dysplasia has an inheritance pattern that is autosomal dominant (Zegarelli et al, 1978), with a high incidence of new mutations at around 20–40% of all cases (Shafer et al, 1983). Several of the cases that have been under our care come from families where a parent was affected, and thus diagnosis was usually (but not always) made at birth. For most of the other cases, a tentative or initial diagnosis was suspected only several years later, by the child's paediatrician or orthopaedist, although the discovery was sometimes made at a dental examination. Corroborative evidence from a clinical

examination and a wider radiological examination was then obtained to establish the definitive diagnosis.

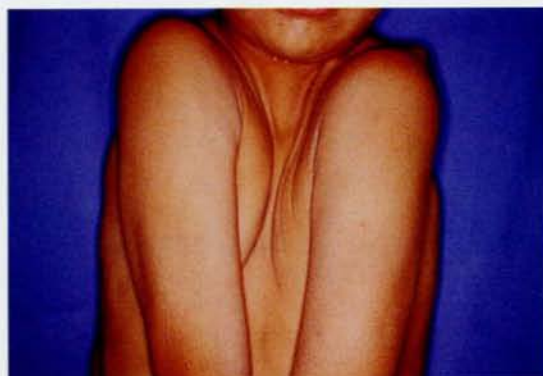
During the physical examination, the clinician should set out to confirm as many of the features described above as possible. In particular, the patient should be asked to approximate the shoulders, to confirm the clavicle anomaly (Fig. 9.1). Palpation should also be made of the area between the parietal bones on the crown of the skull and between the frontal bones at the upper forehead/hairline

region. In both of these midline areas, a smooth and wide hollow, concavity or furrow (Fig. 9.2) may be clearly felt, in contrast to the convex contour of the skull of a normal child. Radiological examination should include views of the clavicles (Fig. 9.3), the fontanelles which may be seen on (Figs. 9.4, 9.5), lateral and postero-anterior cephalometric films (Fig. 9.5), and an initial panoramic film of the jaws (Fig. 9.6).

The signs and symptoms of the condition are very distinct, but entirely benign. They



(a)



(b)

Figure 9.1

(a, b) The approximated shoulders of a cleidocranial dysplasia patient.



Figure 9.2

Frontal midline furrow passing through the hair line.

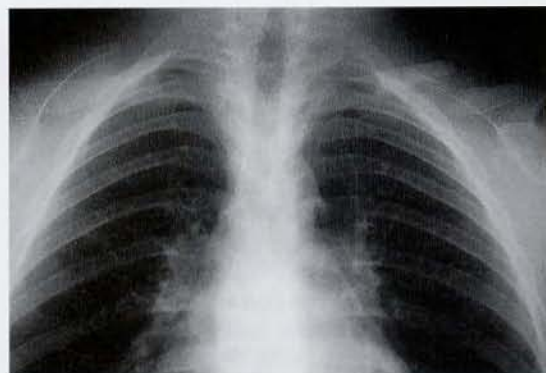
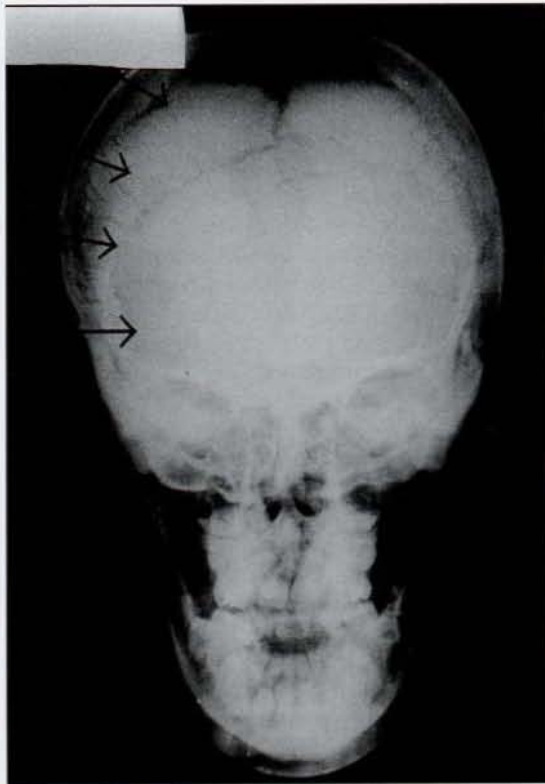
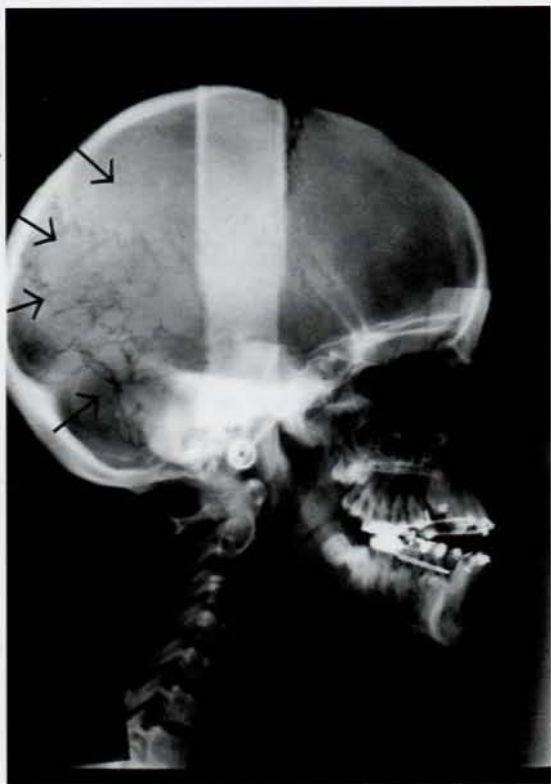


Figure 9.3

Chest radiograph to show incomplete clavicles.



Figures 9.4 (left) and 9.5 (right)

The postero-anterior (left) and lateral (right) cephalograms show abnormal cranial form, open fontanelles and numerous wormian bones (arrowed).



(a)



(b)

Figure 9.6

(a) A 14-year-old female cleidocranial dysplasia patient with a full deciduous dentition and two additional maxillary deciduous incisors. Only one erupted (deeply carious) permanent molar is present. There are 23 unerupted supernumerary teeth, in addition to the 32 unerupted permanent teeth, i.e. a total of 77 teeth! (b) A 13-year-old male cleidocranial dysplasia patient with many erupted permanent teeth and only one supernumerary tooth.

are in no way debilitating or progressive, the patient is not physically or mentally handicapped and other body systems are not adversely affected. Treatment of the overall medical condition is therefore not advised (Shafer et al, 1983; Tachdjian, 1990), and its diagnosis does little more than label the child as an oddity.

The dental aspects of the condition paint a very different picture of the seriousness of the ramifications of cleidocranial dysplasia, since they affect the face and oral structures. From student to experienced practitioner in the dental profession, and out of all proportion to the rarity of the condition, its clinical features are surprisingly well known, again reflecting its curiosity value rather than any ability on the part of the profession to promote change and correction. For many decades, the profession has stood in awe at the enormity of the dental problems that these cases present, unable to offer satisfactory answers.

The dental characteristics include over-retention of the deciduous dentition, non-eruption of the permanent dentition and the presence of many supernumerary teeth. Nevertheless, there is no dental discomfort or disturbance, unless the deciduous teeth become decayed. These teeth are small relative to the growing face, and are not visible below the upper lip, particularly when an often-seen anterior open bite is present. The vertical growth of the alveolar processes is generally deficient, which leaves the patient with a very shallow labial and lingual sulcus in both jaws. Taken together, these features give the patient an edentulous appearance, which may often be the presenting symptom.

Given that

- (a) the child with cleidocranial dysplasia has little by way of a tangible complaint (no pain, no swelling, no difficulty in functioning), yet
- (b) the dentist has diagnosed a benign condition of extraordinary therapeutic magnitude,
- (c) the dentist has no available guidelines on how to even begin to approach the resolution of the enormity of the problem,

- (d) treatment results are impossible to predict for someone who has never before seen such a case, and
- (e) the degree of facial deformity is usually of insufficient consequence to demand surgical modification,

it is entirely understandable that a responsible clinician will hesitate before undertaking treatment.

The alternatives are

- (a) not to offer treatment at all,
- (b) to suggest the more radical approach of extraction of many teeth, followed by prosthetic replacement, or
- (c) to advise an orthodontic-surgical treatment procedure, with an unknown level of confidence in its result.

However, non-treatment becomes less of an option as the patient grows older. Because of considerable occlusal attrition and caries, there is a progressive morbidity of the deciduous dentition, which starts in the early teens and gathers momentum over just a few years. Root canal treatment is often needed, and restoration becomes difficult. The patient's appearance suffers still further, with a reduced lower face height (Smylski et al, 1974), impaired masticatory function, and continuing facial growth contributing to the increasing overclosed appearance. Treatment is needed to provide an efficient masticatory apparatus, and improvements in the dental appearance and the facial proportions.

TREATMENT MODALITIES

These goals may be realized in several ways. The recommended methods that have been proposed over the period of many years have most often reflected the particular area of dentistry in which the treating dentist has specialized. Therefore, to a degree, the mode of treatment may depend upon whose door the patient first knocks!

Removable prostheses

The most popular approach has been to provide the patient with removable partial or full prostheses, which fulfils all the immediate needs of the patient. This approach has been suggested by many only after the removal of all the deciduous teeth and the unerupted supernumerary and permanent teeth (Winther and Khan, 1972; Kelly and Nakamoto, 1974; Yamamoto et al, 1989). Given that the alveolar bone height in these cases is very limited, with shallow sulci, the dentist should ponder the construction of replacement tissue-borne prostheses 10 years later, after additional and iatrogenic ridge resorption has occurred. The absence of alveolar bone and the thinness of the mandible itself will rule out the use of implants.

Others have advised retaining the standing teeth and the construction of prostheses around them (Frommer and LaPeyrolerie, 1964; Hitchin and Fairley, 1974; Kelly and Nakamoto, 1974; Stewart and Prescott, 1976). A further refinement recommends the exploitation of any standing teeth, together with the surgical exposure of unerupted teeth, to serve as supports for an overdenture (Hitchin and Fairley, 1974; Weintraub and Yasilove, 1978; Probst et al, 1991). By making it tooth-borne, the denture is less likely to cause further ridge resorption, but the supporting teeth will deteriorate quickly under these circumstances, both from caries of the crown and the root surfaces and from loss of periodontal attachment.

Surgical relocation

In the search for a non-prosthetic method that utilizes the existing teeth, surgical removal of the supernumerary teeth, followed by careful dissection of the unerupted teeth and their repositioning or transplantation into artificially prepared sockets, has been proposed (Muller, 1967; Oksala and Fagerstrom, 1971; Shafer et al, 1983). However, these studies do not appear to have been reported on following long-term observation, and one is left to

presume that the transposed teeth will, in time, undergo fairly rapid pathologic root resorption, as seen with other transplanted teeth.

These methods all suffer one serious drawback, namely that the results thus achieved deteriorate in time and their prognosis is relatively poor. When one considers that treatment for the condition is required in the patient's second or third decade of life, these modalities must be considered to be of limited value and essentially inadequate to the task.

Orthodontics and surgery

Before the mid-1960s, while some limited positive results were obtained with orthodontics, the idea was considered to be impractical and fanciful, and was widely derided. Nevertheless, it caught the imagination of several clinicians, and, particularly in the late 1970s and early 1980s, several publications appeared advocating a surgical and orthodontic method. The method used to bring about the eruption of the teeth was to extract the deciduous teeth, surgically remove the unerupted supernumerary teeth and expose the buried permanent teeth, with or without the use of a surgical pack, depending on the depth of the individual teeth within the tissues (Elomaa and Elomaa, 1967; Smylski et al, 1974; Hall and Hyland, 1978; Frame and Evans, 1989).

The patient was then seen in routine follow-up visits, until the teeth erupted or had reached a sufficiently accessible position, occlusal to the healed gingival tissues, for the application of orthodontic bands or bonded attachments. In other words, assisted eruption was only provided for those teeth that had already partially erupted. For these cases, characterized as they are by a lessened power of eruption, many months will pass before teeth appear, and some of the more deeply sited teeth may never erupt. Additional surgical exposure is needed for some of these, but still with no guarantee of success.

Immediate bonding and ligation at the time

of surgery for these cases was introduced in the literature in the 1980s, when Trimble et al (1982) and Davies et al (1987) each showed a single case in which this was done. The advantage of being able to apply forces to the most intractably impacted teeth is well illustrated in these two cases.

The results and prognosis that may be achieved by a method involving surgical removal of the unwanted deciduous and supernumerary teeth, followed by the orthodontically assisted eruption and alignment of the natural permanent teeth, must be viewed as warranting exploitation. What, after all, could be better than to restore the dentition with the patient's own teeth and with normal alveolar bone support, through the medium of a healthy periodontal ligament?

Since the orthodontic literature records few attempts to standardize orthodontic treatment strategy, beyond the above-mentioned single case reports, it must be concluded that the orthodontic option is not exercised for many cases and that there seem to be few centres around the world where a significant group of patients of any size has been treated. For these reasons, the present state of opinion regarding recommended or appropriate procedure is difficult to assess accurately.

Nevertheless, within this modality, three different courses of action have been suggested over the past few years, each based on the experience of the treatment of several cases and each with its own relative merits. These will be referred to as:

- the Toronto-Melbourne approach;
- the Belfast-Hamburg approach;
- the Jerusalem approach.

THE TORONTO-MELBOURNE APPROACH

This method was originated by a team from Toronto (Smylski et al, 1974) and was later further developed in Melbourne (Hall and Hyland, 1978). Surgical procedures are performed in a stage-by-stage series, under endotracheal general anaesthesia, with the

degree of root development of the permanent teeth dictating the timing of each stage.

Thus, initially, the deciduous incisor teeth are extracted at 6 years of age, followed by the deciduous canines and molars at 9-10 years. Supernumerary teeth overlying the crypts of the unerupted permanent teeth are removed together with 'substantial amounts of bone to uncover the crowns (of the permanent teeth) to their maximum diameter'. The teeth are left widely exposed. The Melbourne team prefers to expose the incisors at a separate and additional surgical episode, and this is done after the first molar bands are placed, following the late eruption of these teeth, which may reach full expression only at about the age of 10-11 years. Surgical packs are used to maintain the patency of the surgical exposure and to safeguard access for eventual bonding of the teeth.

The expectation is that, following the removal of the obstructive elements, i.e. the deciduous and supernumerary teeth, together with a liberal amount of bone and soft tissue, the teeth will then erupt 'under their own steam' to a varying degree and over an extended time frame. When convenient, orthodontic brackets are bonded to individual teeth, and these are drawn to a light archwire, which spans the unsupported premolar/canine areas, from the banded molars to one or more anteriorly erupted incisors. Teeth are then drawn to the archwire, depending on their becoming accessible to bracket bonding.

Smylski et al (1974) and Hall and Hyland (1978) do not propose any special or purpose-designed appliances to deal with the vertical traction that is needed in every area of the mouth, but appear to rely on the employment of conventional methods used in routine orthodontic treatment.

Limitations

In this method, the patient is under treatment for many years, beginning at a very early age and requiring several recommended and fairly extensive surgical interventions, fol-

lowed by several smaller ones for individual teeth. The age of the patient in the early stages and the scope of the surgery are the major determinants as to whether these need to be carried out under general anaesthetic.

The deciduous anterior teeth are removed at an early stage, in order to encourage the eruption of permanent incisors. Nevertheless, in their subsequent recommendation to fully expose the permanent incisor teeth in a distinct and separate surgical stage, Smylski et al (1974) and Hall and Hyland (1978) recognize that spontaneous eruption does not always occur. This means that the patient is anteriorly edentulous for some considerable time. This would seem a high price to pay for what may be undue optimism regarding the potential in cleidocranial dysplasia for normal eruption. In two of the three cases described in Smylski et al (1974), unerupted supernumerary teeth were not present in the anterior segments, and the permanent incisor teeth responded to simple exposure and packing. However, there are many cases where spontaneous eruption does not occur, this being one of the diagnostic criteria of the condition, which may be associated specifically with the frequent presence of supernumerary teeth in this region.

The placement of attachments to the deeply sited permanent teeth is not performed at the time of surgery, but only some time later, after full healing (by secondary intention) has occurred and the surgical packs have been removed. Thus, at each surgical stage, valuable time is lost between the exposure and the force application needed to encourage the eruption of the teeth.

THE BELFAST-HAMBURG APPROACH

Simultaneously, but quite independently, Richardson and Swinson (1987) of Belfast and Behlfelt (1987) of Hamburg proposed a diametrically opposite method of treatment of cleidocranial dysplasia. They recognized that, while there is the need for extensive surgery in these cases, this could all be completed at one time, including the extraction of all decid-

uous and supernumerary teeth and the exposure of all unerupted permanent teeth. This is carried out under general anaesthesia, under operating theatre conditions and with surgical packs placed over the remaining teeth to encourage epithelialization of the exposed tissue, which is the essence of healing by secondary intention.

During the succeeding weeks, these surgical packs remain in place and perhaps changed over a further shortish period, until brackets may be conveniently bonded to the exposed teeth. This can then be done under what the proponents consider to be more reliable conditions for bonding than those present during the surgical procedure.

Whether or not eruption of these teeth occurs without assistance is the subject of some debate, with one source insisting that, while there is apparent improvement, this is due to the radical loss of surrounding soft and hard tissue during the surgical procedure, rather than actual vertical dental change (Miller et al, 1978). Nevertheless, even with the most favourable and optimistic assessment, there can be no doubt that the eruption will be neither sufficient nor reliable enough to eliminate the need for extrusive mechanics. As with the Toronto-Melbourne approach, appliances consist of molar bands and bonded brackets, with long spans of unsupported and relatively fine archwire used to vertically develop the partially erupted teeth.

Limitations

By recommending all extractions and exposures at one time, the Belfast-Hamburg surgical policy has clear advantages from the patient's point of view, although a balance has to be struck in terms of timing this procedure. The earlier-developing permanent teeth (particularly the incisors) should not be exposed too late in their development to lose any eruptive potential that they may have, while the later-developing teeth should not be exposed too early while their roots are insufficiently developed. Accordingly, the Belfast team (Richardson and Swinson, 1987)

recommends that the one-time, comprehensive, surgical intervention be performed at age 12–14 years.

The immediate advantage of this policy is very clear and encouraging, although its drawbacks are of considerable consequence and not so obvious. By delaying treatment until this late age, the teeth of the normal series will have been held deep down in basal bone by the supernumerary teeth, particularly in the lateral incisor/canine/premolar area, for an extended period of time. Their roots will have reached an advanced stage of development in these cramped circumstances, which is likely to exaggerate the existing tendency for a stunted, tortuous and distorted root morphology (Becker and Shochat, 1982). Removal of the unwanted extra teeth at this late stage will relieve the impaction of the permanent teeth of the normal series, but it will do so at a time when they exhibit even less potential for spontaneous eruption, particularly in the incisor region, since the root apices will already have been completed.

During growth in a normal child and with the eruption of permanent teeth, the vertical development of the alveolar processes that occurs makes a significant contribution to the height of the lower face. It also leads to the establishment of deep vestibular and lingual sulci, with a clear differentiation of wide zones of oral mucosa and attached gingiva. In the untreated cleidocranial dysplasia patient, vertical growth of the alveolar bone appears to be markedly diminished. This brings about the typically reduced height of the lower third of the face that is so frequently a feature of the condition. Thus, with the late removal of the unwanted deciduous and supernumerary teeth at a time when most of the patient's growth has already occurred, the ultimate vertical alveolar growth that accompanies the erupting permanent teeth will be correspondingly less, leaving a shallower sulcus, an absence or reduced width of attached gingiva and an incompletely vertically developed lower third of the face, in the final analysis.

Furthermore, and in addition to removing the unwanted supernumerary teeth, it is necessary to gain access to the canine and premolar teeth of the normal series and to expose

them widely. When the procedure is performed at this late stage, these target teeth are very deeply situated, often with their developing root apices close to the lower border of the mandible. This necessitates the removal of considerable quantities of bone (Smylski et al, 1974) and, as recommended by several authors, the placement of a surgical pack over and around the crowns and necks of the teeth to prevent bony healing-over and to encourage spontaneous eruption. This packing procedure will markedly delay healing, and is designed to prevent the reparative filling-in of bone. It is difficult under these circumstances to avoid pushing the pack into the area of the CEJ, which will inevitably lead to a poor periodontal prognosis for the finally erupted tooth, with an exposed CEJ and lessened bone support (Kohavi et al, 1984).

The frequent need to change packs over a long period incurs pain, discomfort and nuisance, difficulty in maintaining oral hygiene, and a limitation of normal function, with a long-term bad taste and odour in the mouth due to the unhygienic circumstances. From the surgeon's point of view, this entails seeing the patient for many time-consuming appointments. There is no active encouragement of eruption until brackets may be successfully bonded and traction applied, in a case already afflicted by slow or non-eruption as a characteristic of the disease. Thus, at an age when facial appearance is very important, the patient will spend an unacceptably long time without teeth. Furthermore, bone regeneration will have been slowed down by the use of a method involving healing by secondary intention (Howe, 1971). Eruption is thus delayed and a growing over of the soft tissues, to re-cover the deeper and newly exposed teeth, may still occur.

It becomes clear that surgical policy is governed by the willingness of the operators to place attachments at the time of surgery. Without them, access to the unerupted teeth must be guaranteed by the surgeon performing wide opening and radical bone resection, with the placement of surgical packs. With them, a conservative surgical policy is possible – only enough bone is removed to allow access for the placement of a small eyelet

attachment on the minimally exposed tooth surface. The surgery may then be aimed at preserving rather than removing bone, since the presence of bone does not seem to hinder mechanically encouraged eruption of the teeth in these cases. Its lack would be a greater drawback in terms of the eventual degree of bone support and thus of the periodontal prognosis of the erupted teeth (Kohavi et al, 1984).

It has been reported (Smylski et al, 1974) that denser alveolar bone is present in cleidocranial dysplasia. We have not found abnormal bone in any of the cases in our care, although the observer could understandably be misled by the fact that cortical bone is found, to the relative exclusion of spongiosum. It should be remembered that the impaction of many teeth within the jaws takes up much of the volume within the body of the mandible where spongiosum would normally be present. Thus, while cortical bone encompasses all these teeth and is present in normal amounts, spongiosum is sparse.

THE JERUSALEM APPROACH

This method (Becker et al, 1997a,b) was presented for the first time at the same forum as the Belfast-Hamburg approach, described above (Becker and Shteyer, 1987). Its modus operandi is quite different from either of the two earlier approaches. The Jerusalem approach is based on a rationale that is related to the abnormal dental development of the patient and on the factors that produce it.

This comprehensive approach to treatment addresses the following points:

- (a) a recognition of the clinical features of the facial, oral and dento-alveolar structures in the disease;
- (b) the surgical measures that are required to provide access to the areas concerned;
- (c) the need for an orthodontic strategy to enable the application of extrusive mechanics to the buried teeth in an efficient and reliable manner;

- (d) attending to the patient's psychological well-being by focusing the earliest stages of treatment to the resolution of the incisor impactions.

Clinical features

Cleidocranial dysplasia patients exhibit each of the following features to a variable degree:

- (a) non-resorption of deciduous teeth roots;
- (b) presence of supernumerary teeth, markedly displacing the developing permanent teeth and providing a physical barrier to their eruption;
- (c) lessened eruptive force, although eruptive movements are evident;
- (d) poor vertical development of alveolar bone, as witnessed by a shallow sulcus, a reduced height of the lower face and a Class III skeletal tendency, due to an underdeveloped maxilla and to a counterclockwise mandibular rotation;
- (e) late but normal and unhindered eruption of first and, sometimes, second permanent molars in both arches;
- (f) late dental development, as judged by the root development of the permanent teeth, whether erupted or unerupted – a 12-year-old patient will typically show a dental age more appropriate to that of a 9 year old (Hall and Hyland, 1978; Becker et al, 1997b; Seow and Hertzberg, 1995).

Surgical therapeutic measures

The timing regarding the actual exposure of the permanent teeth is critical, and only two interventions are planned at distinct points in time, depending upon the extent of root development, as follows.

Intervention 1

At the dental age of 7–8 years, the anterior deciduous teeth, together with all the supernumerary teeth, in both the anterior and

posterior areas, are extracted. The anterior permanent teeth, whose roots are sufficiently developed (two-thirds their expected length) are surgically exposed, attachments are placed immediately and flaps fully closed. Given the usual lateness in development of the dentition in these cases, the chronological age of the patient at this stage is usually around 10–12 years. At this time, the posterior permanent teeth are at an early stage of development, with their roots less than half their expected final length. The surgical intervention in the premolar/canine region is therefore limited to removal of supernumerary teeth. Actual exposure of the developmentally immature posterior teeth of the permanent series is not undertaken, and their dental follicles are left intact until a later time.

Intervention 2

The dental age of 10–11 years (chronological age 13+ years) is the most appropriate time for the second intervention, because the root development of the posterior successional teeth will be sufficiently well advanced, and eruption and alignment of the incisor teeth will have been achieved. This intervention involves the exposure of the teeth in the canine/premolar regions and the immediate placement of orthodontic attachments. The special requirements of the surgical procedure relate to the conservation of bone in general and of the cortical part of the bone in particular. Removal of the unerupted supernumerary teeth with a minimum of buccal plate of bone creates enough space around the crowns of the impacted permanent teeth of the normal series to allow the immediate bonding of attachments. The lingual plate is left intact and at its original height. Maxillary second premolars may require a palatal approach, in which case the buccal plate is left intact.

Liberal soft tissue exposure of the surgical field is advised, to enable good vision and access and to help in maintaining the conservative attitude to the removal of bone. The muco-periosteal flaps are finally replaced intact and sutured back, without the use of packs, in the manner of primary soft-tissue

closure (Becker and Zilberman, 1978; Becker et al, 1983; Kohavi et al, 1984; Vermette et al, 1995).

Immediately following the first intervention, it becomes necessary to supplement the eruptive force of the incisors. In this way, the vertical migration of the teeth that rapidly occurs brings with it a pronounced vertical development of the alveolar bone (Smylski et al, 1974). This is all planned when root development is between half and three-quarters, which corresponds to the stage of development at which teeth normally erupt (Gron, 1962). Similarly, occlusally directed forces are applied to the posterior teeth immediately following the second intervention.

Orthodontic requirements

In the broad overview, the provision of space within the arch is made by appliance-generated antero-posterior expansion of posterior-versus-anterior erupted teeth (Elomaa and Elomaa, 1967), while the removal of deciduous and supernumerary teeth provides space in the vertical plane. In this way, and while space is being provided, self-realization of any eruptive potential that the permanent teeth may possess is permitted, to present the opportunity for them to migrate towards the occlusal plane and to take up a more normal developmental position within the alveolus. This seems to occur to a varying degree, to allow the roots to develop in uncramped circumstances and thereby lead to the acquisition of a more normal root morphology (Becker and Shochat, 1982). However, it is important to emphasize that no reliance is placed on spontaneous eruption of these teeth (Smylski et al, 1974) although, should this occur, it is only to be welcomed and will simplify the treatment plan. However, the Jerusalem approach has been formulated to combat the worst eventuality, i.e. non-eruption.

From the point of view of the orthodontic mechanotherapy, achieving efficient force application in an appropriate direction for

each tooth requires examination of the following points.

- (a) There must be a sufficient number of erupted anchor teeth in the mouth to act as a base from which forces may be generated. As we have already pointed out, the permanent molars usually erupt without help, and one or two incisors may also be visible.
- (b) One has to design a rigid appliance frame that will endure chewing and other functional and parafunctional movements that may be expected to occur during everyday oral function, considering the long spans of free, unattached and unprotected archwire, mesial to the few erupted anchor molar teeth.
- (c) Individual and groups of unerupted teeth must be subjected to light continuous forces.
- (d) Appliance design has to feature sufficient versatility to enable it
 - (1) to apply vertical extrusive forces to erupt the impacted teeth rapidly;
 - (2) to open spaces between recently erupted teeth, to provide room for other unerupted teeth and to establish interproximal contacts and arch form;
 - (3) to bring these teeth into occlusion and to upright their roots
 ... and all this with only minor alterations!

The patient's psychological well-being

In Chapter 5, we pointed out that it is inadmissible to leave even the youngest patient without front teeth for an extended period of time, and that it is important to make the child aware that efforts are being made to rectify such a situation speedily. The physical obstacles to eruption (i.e. the deciduous and supernumerary teeth) must be removed, in order to facilitate the eruption of the anterior teeth. Proper timing is critical. This should only be done at the age when the permanent incisor teeth indicate adequate root develop-

ment for eruption and only when an appliance is in place, to actively supplement their limited eruption.

DENTAL CROWDING

When studying the radiographs of an untreated cleidocranial dysplasia patient, one is immediately struck by the intra-bony crowding provided by the large number of unerupted permanent teeth (those of the normal series and the supernumeraries). During surgery and after all of the superfluous deciduous and supernumerary teeth have been removed, the surgeon and the orthodontist will view the open surgical field, and, given the relatively under-developed alveolar processes, will find it difficult to see how it is possible to fit all the remaining permanent teeth into the dental arch and in full alignment.

On the basis of this 'spot' diagnosis, the orthodontist will be tempted to advise the oral surgeon to take advantage of the prevailing general anaesthetic to remove a premolar tooth in each quadrant of the mouth, in what would appear to be a logical step necessary to reduce the apparent crowding. However, for most cases, this step would be regretted later when the subsequent size and form of the alveolar processes, which may be developed as a by-product of the mechanical eruption of the teeth, become evident.

Initially, the appliance-generated eruption of the anterior teeth brings the teeth into the mouth, with a pronounced lingual tipping of their long axes. This is due to the influence of purely vertical forces that will have been brought to bear on the permanent incisors, whose developmental position is very much lingually placed and apical to the recently extracted deciduous incisors.

For this reason, the permanent incisors must be tipped labially, to create a normal arch form and to provide a more procumbent support for the lips. This will contribute much additional space in the dental arches for the premolar and canine teeth, and will be instrumental in significantly eliminating the

dental crowding and the patient's edentulous appearance. It is only after complete or almost complete eruption has occurred that a decision should be made as to whether extractions are needed. Our limited experience has shown that, in these younger patients, extractions are not needed in the final analysis and that adequate space for alignment of all the teeth anterior to the first molars may easily be provided.

RETENTION OF THE TREATED RESULT

Once the permanent teeth have all reached their final positions in the arch, the removal of the fixed appliances will not usually be accompanied by a loss of vertical height of these teeth, despite the fact that their vertical positions will have changed so drastically over the treatment period. The lateral width of the two arches will have been set initially by the first permanent molars and the over-retained deciduous teeth. The use of fixed lingual arches during treatment will have allowed good control against any change in this dimension. Therefore the orthodontist may confidently expect no natural post-treatment alteration of the arch width.

The only dilemmas of any consequence in the context of retention relate to the labio-lingual post-treatment position of the incisors of both jaws and to those teeth that have undergone rotational orthodontic movement during treatment.

It is axiomatic to say that proper labio-lingual positioning of the anterior teeth in any patient is dependent on the muscular balance between the lips and the tongue. Teeth placed too far labially or lingually will inevitably be pushed by the lips or tongue in the opposite direction, when all retaining devices are removed. During the orthodontic treatment of the normal patient and in the interests of stability, the positions of adjacent teeth are often used as a yardstick to which the displaced teeth should be moved to achieve the desired alignment. Alternatively, cephalometric standards may be preferred against which to compare the dentition, such as the lower

incisal edges vis-à-vis the A-Po line (Ricketts, 1981).

With the cleidocranial dysplasia patient, there is no scientific way to judge the 'biologically correct' and therefore stable position of the incisors. Nor are there any published cephalometric data on a large group of treated and post-retention cleidocranial dysplasia patients, to help establish such 'norms'. By no means may the cephalometric values of these patients be compared with the average values found in the various growth studies that have been carried out with samples of normal patients. Consequently, the use of Holdaway or Ricketts analysis and a growth prediction analysis, as proposed elsewhere (Hall and Hyland, 1978), is completely invalid and highly misleading. The orthodontist can never be sure of the stability of the final result in this aspect of the treatment, and some form of long-term retention will usually be advisable.

This being so, we have adopted the view that the incisors should be brought well forward, extruded below the upper lip, to slightly over-compensate to some degree for the years that the patient has lived with very short and largely invisible teeth. When only deciduous teeth were present, or in the initial stages of treatment, the patient's social interaction with others will have been dictated by a desire to mask the missing anterior teeth, and he or she may have adopted unnatural and unsmiling facial expressions and a retiring attitude. Once the teeth alignment has been completed and appliances removed, a positive and dramatic psychological change in patients' attitude to life seems to occur, and, from then on, many seem to walk around with a permanent smile on their faces, consciously and deliberately displaying their new-found teeth!

After a short period of time with conventional removable retainers, our practice has been to prepare and apply fixed multi-stranded bonded retainers to the maxillary and mandibular six anterior teeth (Zachrisson, 1977; Becker and Goultschin, 1984; Becker, 1987). These will then hold the labio-lingual positions of all the anterior teeth, as well as preventing rotational relapse. The conven-

tional removable retainers may then be discarded.

THE JERUSALEM APPROACH IN CLINICAL PRACTICE

Patients who are suspected to be suffering from cleidocranial dysplasia are referred to us through different agencies, including the various medical specialties and general dental practitioners or dental specialists. A small proportion also arrive on their own initiative, requesting advice and help in the search for a solution to the presence of 'very small teeth' or to their 'toothless' appearance.

In order to first confirm that the patient does indeed suffer from cleidocranial dysplasia, our diagnostic routine has come to include

- (a) a clinical examination in search of the general characteristics of the condition, which takes in the form of the cranium, the face and the clavicles, including the mobility of the shoulders;
- (b) an intra-oral examination to relate the eruption status of the dentition vis-à-vis the patient's chronologic age;
- (c) a radiographic evaluation, which plays a critical role in the confirmation of the clinical diagnosis, includes a chest X-ray and antero-posterior and lateral skull radiographs, which are performed in a cephalostat.

At the same time, a panoramic radiograph is studied and supplemented with periapical and occlusal views, as required.

Once the diagnosis has been confirmed, genetic counselling is offered to the parents regarding their own future offspring, but more particularly regarding offspring of the affected child. An important part of the geneticist's examination will include gathering information about relatives and the possibility that other, more distant, family members may be similarly affected. Treatment of the condition will involve the talents of a team of three dental specialists, working in close collaboration, and the first stage may begin immediately.

Stage 1: Assuring the health of the dentition

Treatment of the cleidocranial dysplasia patient will necessitate the wearing of orthodontic appliances for several years. Therefore an essential requirement in all cases is that the health of the dentition be guaranteed by proper oral hygiene instruction, with follow-up to check that an adequate level of compliance is attained. Appropriate use of fissure sealants and fluoride applications is recommended. Carious teeth will need to be treated, but, in order for the paedodontist to be in a position to decide on the type of restoration indicated, the timing of the extraction of the remaining deciduous teeth will need to be determined at the outset.

Stage 2: Vertical correction in the incisor region

For most cleidocranial dysplasia cases, at dental age 7–8 years, all first permanent molars will have erupted. Sometimes, one or more of the permanent incisors will also have erupted, but the following description of the technique will assume the least favourable initial scenario.

Orthodontics

Plain orthodontic bands are fitted on the erupted first molars (Fig. 9.7), and a compound impression is taken of each dental arch. The bands are then carefully seated in the impressions, and a model is cast. Heavy soldered palatal and lingual arches are prepared on the two models, and single soldered buccal tubes (0.036" round) are located running mesially, close to the buccal side of the deciduous teeth, parallel to the occlusal plane. A misplaced first permanent molar may need to be aligned with a removable appliance first, in order to be able to align the buccal tubes accurately as described, since the efficient working of the appliance depends on this.



(a)

Figure 9.7

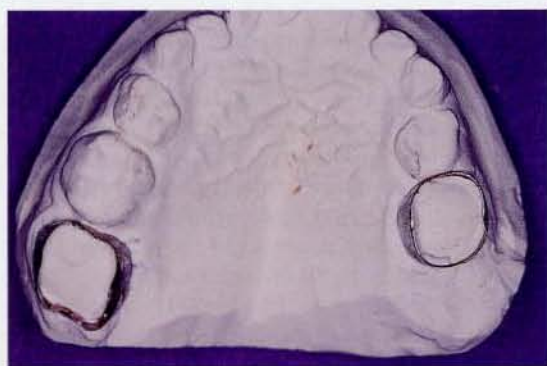
(a) Plain bands have been adapted to the maxillary left second deciduous molar and the first permanent molars in the other three quadrants. (b) An upper (shown here) and lower compound impressions are made. (c) The bands are removed from the mouth and carefully replaced in the impression. The bands are then partially filled with wax, before a model is poured. (d) The cast model with accurately located and stabilized molar bands. (e) The occlusal view of the mandibular model shows right and left tubes converging in the midline and the lingual arch in place. (f) The heavy 'incisor-erupting' archwire is slotted into the molar tubes. Note the S-shaped hook soldered in the canine area and the anteriorly soldered fine-wire frame. (g) Disassembled mandibular appliance ready for intra-oral placement. (h,i) The appliances cemented in the mouth.



(b)



(c)



(d)



(e)

(Figure 9.7 continued)



(f)



(g)



(h)



(i)

A heavy 'incisor-erupting' archwire is prepared for each arch in advance (Fig. 9.7f), and its function is to achieve a correction in the vertical plane. This archwire is made of 0.036" round wire, which slots into the buccal molar tubes up to a predetermined bayonet bend on each side. This holds the wire 2–3 mm labial to the anterior teeth and 3–4 mm gingival to the occlusal plane. In the canine area, an S-shaped hook is soldered, with its mesially pointing extremity on the occlusal side and the distally pointing extremity gingival. In the midline area, a small fine wire frame is also soldered, and points towards the sulcus depth.

An 'incisor-aligning' archwire is also prepared in advance, although it will not be put

to use until all the permanent incisors have been fully erupted. This consists of 0.020" internal-diameter tube side pieces, which freely slide accurately into the 0.036" buccal tubes, without allowing lateral 'play'. The tubes are cut so that their mesial extremity is in line with the distal of the deciduous canine. A length of 0.0155" or 0.0175" multistranded wire is then drawn into the buccal side-piece tubes, and is made to 'friction-fit' by incorporating three or four sharp bends in that part of the wire. This updated version of Johnson's twin-wire arch (Johnson, 1934; Shepard, 1961) is placed to one side until it is needed at that later stage, when it will be used to achieve correction of the alignment of the teeth in the horizontal plane.

Surgery

The patient is now ready for the first surgical intervention (Fig. 9.8), at the completion of which the patient will have lost all of the anterior deciduous teeth and will also have had the unerupted supernumerary teeth removed. Fine pigtail ligatures will have been placed in the eyelet attachments bonded to the incisor teeth, and these will be the only link between the invisible unerupted permanent teeth and the exterior (Fig. 9.9). Deciduous teeth not associated with supernumerary teeth are generally left until the next surgical

stage. The surgical flaps are fully sutured back.

Orthodontics

Still under the endotracheal anaesthesia, in the operating theatre, the prepared 'incisor-erupting' archwire is placed in the buccal tubes and secured by drawing a chain elastic module between the distal of the buccal tubes to the mesially pointing extremity of the S-hook. The archwire is raised with light finger pressure, and engaged by looping the pig-



(a)



(b)



(c)



(d)

Figure 9.8

A 14-year-old patient. (a-c) Intra-oral views of initial condition. (d) Anterior intra-oral view of appliances in place.

tail ligatures around it. Since these pigtailed are tied directly to the buried incisor teeth, this displacement of the archwire elicits a vertical extruding force on the unerupted teeth (Fig. 9.9c).

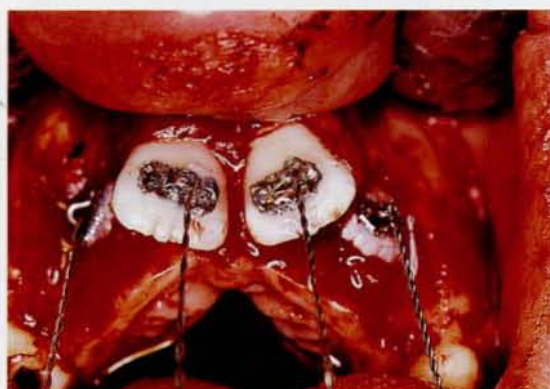
This force generates a rapid response of the teeth, as witnessed by elongation of the pigtail ligatures, over a period of a few weeks. By displacing the archwire apically and then 'rolling up' the pigtail around it, extrusive pressure may be reapplied over several visits, until eruption occurs. To support the orthodontic anchorage, a large fine-gauge elastic should be used to engage the distal pointing hooks on each side of the maxillary and

mandibular archwires. This 'box elastic' provides an intermaxillary vertical force to each archwire. If the midline portion of the stretched elastic is laid over the soldered vertical frame, tissue impingement may be avoided (Fig. 9.10).

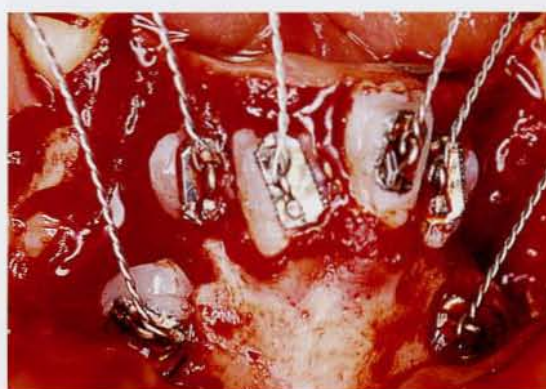
Stage 3: Horizontal correction in the incisor region

Orthodontics

The incisors erupt relatively quickly and with a strong lingual inclination, in general. At that



(a)



(b)



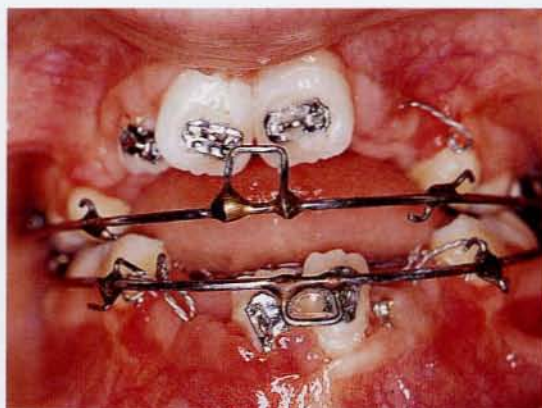
(c)

Figure 9.9

The same patient as in Fig. 9.8. (a) Four maxillary incisors have been exposed and attachments bonded. (b) Six mandibular anterior teeth have been exposed and attachments bonded. The exposed chin button and the lingual arch indicate the depth of these teeth. (c) The 'incisor-erupting' archwire is replaced when full-flap suturing is completed, and the steel ligature pigtailed are made to ensnare the archwire, which has been displaced superiorly by light finger pressure.



(a)



(b)



(c)

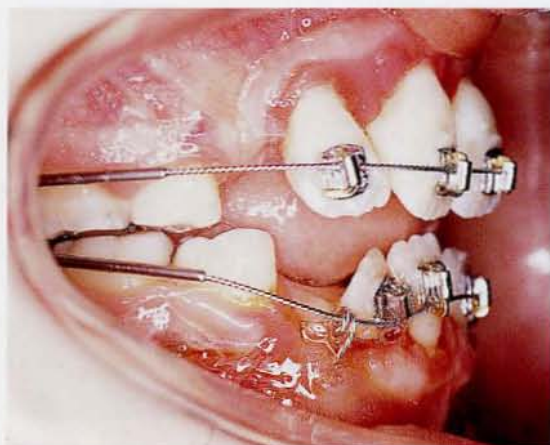
Figure 9.10

The same patient as in Figs 9.8 and 9.9. (a) At 5 weeks post-surgery, a very light anterior 'box elastic' is placed on the distally pointing element of the S-hooks in the canine areas to enhance the anchorage. Note the use of the midline frames to prevent tissue impingement. (b) At 9 weeks post-surgery, five incisors have erupted, and the archwires have been disengaged to increase their deflection. (c) Re-engaging the archwires illustrates their range of effectiveness.

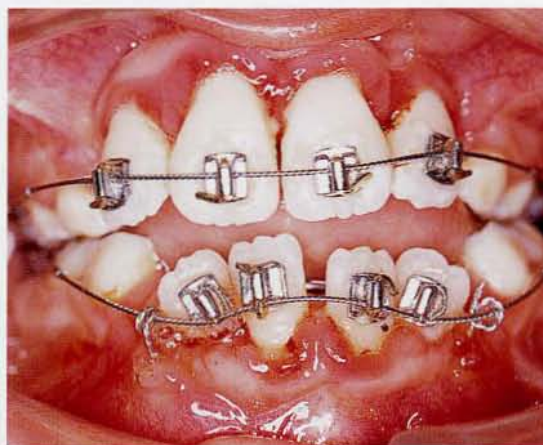
point, their eyelets should be replaced by the orthodontic bracket of the orthodontist's choice, which should be sited in the routine manner (Fig. 9.11). The prepared 'incisor-aligning' archwire is then tied or pinned into place, where its first task will be to undertake the levelling phase of treatment, i.e. incisor height, rotation and, in the edgewise techniques, uprighting. With proper buccal tube orientation at the outset, the long buccal tube side pieces maintain the achieved vertical extrusion, while providing resistance to distortion and stability. The light 'box' elastics

may be attached to the lateral incisor brackets, to continue the vertical extrusive force, if and when necessary.

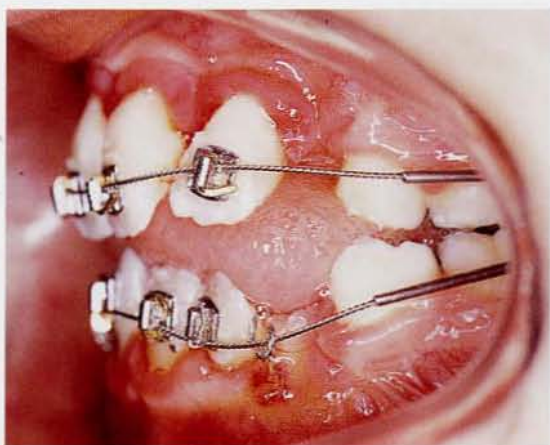
As levelling proceeds, the middle portion of the 'incisor-aligning' archwire may be substituted for heavier and thicker wires (Fig. 9.12) until an 0.018" or 0.020" wire is in place, using the same side pieces. At this point, an expanded coil spring is placed on the side pieces, which now have a 'stop' placed on their mesial end. When the side pieces are replaced in the buccal tubes, the coil spring is compressed between the buccal tube and the



(a)



(b)



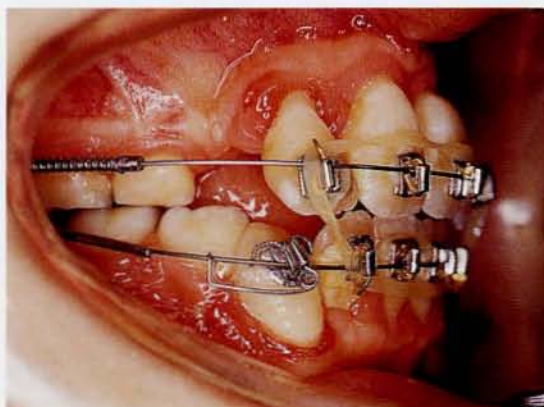
(c)

Figure 9.11

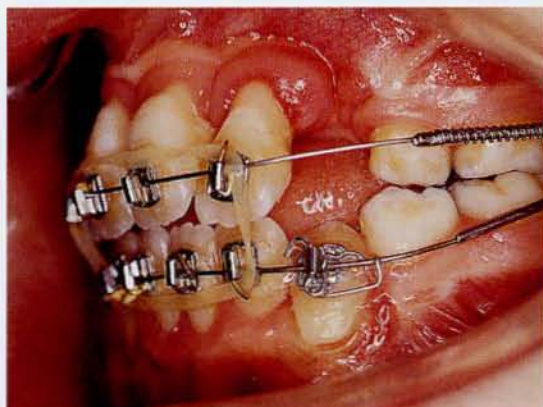
The same patient as in Figs 9.8–9.10. (a–c) At 6.5 months post-surgery, all incisors have erupted. Conventional brackets have been substituted for the eyelet attachments, and the 'incisor-aligning' archwires are in place. Note the extrusive component generated by these archwires.

mesial stop, which displaces the archwire forwards. The archwire is tied into the anterior brackets under pressure. The compressed coil spring is now producing an antero-posterior expansion force, acting between the first molars and the incisors. This rapidly tips the incisors to a more normal labial inclination, enlarging the space for the unerupted canine and premolar teeth. Archform will be greatly enhanced and the patient's appearance will, for the first time, begin to markedly improve.

An estimate of treatment time up to this point (stages 2 and 3), would be between 9 and 18 months. New radiographs should now be taken of the unerupted canines and premolars (Fig. 9.13) to determine the state of their root development and to reassess their vertical location within the alveolus. The absence or earlier removal of supernumerary teeth in this area, together with an increase of space in the arch and the passage of time, may have led to an improvement in their position, which should be recorded.



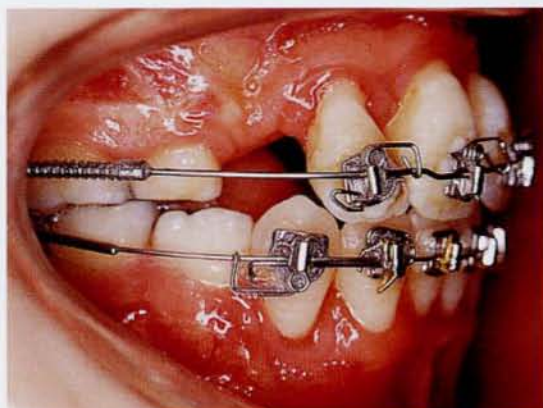
(a)



(b)



(c)



(d)



(e)

Figure 9.12

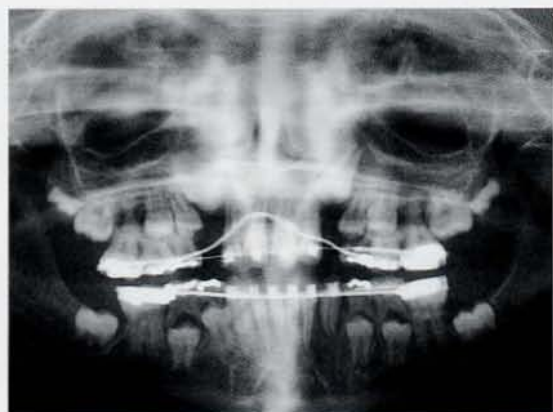
The same patient as in Figs 9.8–9.11. (a,b) At 15 months post-surgery, the incisors have been moved labially, aligned, and a positive overbite/overjet relationship has been established. In this particular case, the mandibular canines were included in this stage of treatment. Note the severe mesial root displacement of these teeth. (c) The occlusal view of the mandibular anterior teeth indicates gross labio-lingual displacement of the roots of the lateral incisors and canines. (d,e) Following 4 months of further treatment, the root displacements have been corrected. This was done during a waiting period for adequate pre-molar development, to allow the initiation of the second surgical intervention.



(a)



(b)



(c)

Figure 9.13

The same patient as in Figs 9.8–9.12. (a) A panoramic view taken 10 months pre-surgery. (b) A similar view 6 months post-surgery. (c) A similar view 21 months post-surgery.

Stage 4: Vertical correction in the posterior region

Surgery

The second surgical intervention (Fig. 9.14a) is performed at dental age 10–11, and it will leave the patient devoid of the remaining deciduous teeth. The surgical flaps will have been replaced to completely cover the eyelet attachments bonded to the unerupted permanent teeth, and stainless steel pigtail ligatures will be visible emanating through the sutured edges of the wound.

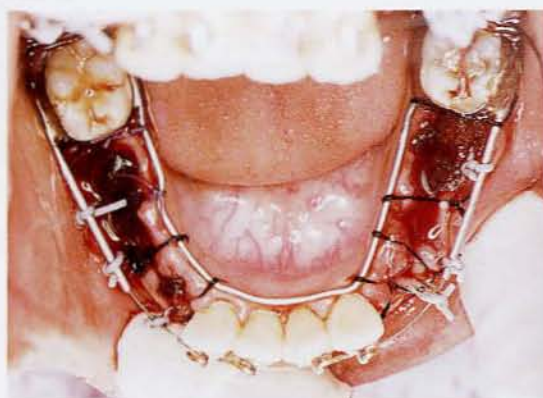
Strictly speaking, the scope of this surgical procedure, potentially involving 12 teeth (8 premolars and 4 canines in the four quadrants) is large enough to warrant endotracheal anaesthesia and operating theatre conditions. However, in the more favourable cases, much improvement will have occurred over the period of time since treatment was originally initiated, and several teeth may have partially erupted. This may encourage the oral surgeon to prefer to perform the remaining exposures under local anaesthetic, one or two quadrants at a time.



(a)



(b)



(c)

Figure 9.14

(a) In this patient, the second surgical intervention is typically aimed at exposing and bonding the canines and premolars in all four quadrants. Note that only a minimal exposure of the buccal surfaces of the teeth is performed. The alveolar bone superior to the teeth is left untouched, as are the entire lingual bone and the gingival attachments of the extracted deciduous molar and canine teeth. (b,c) The buccal surgical flaps have been sutured across the ridge to the lingual arch. Elastic thread draws the unerupted teeth to the rigid buccal arms of the 'incisor-aligning' archwire.

Orthodontics

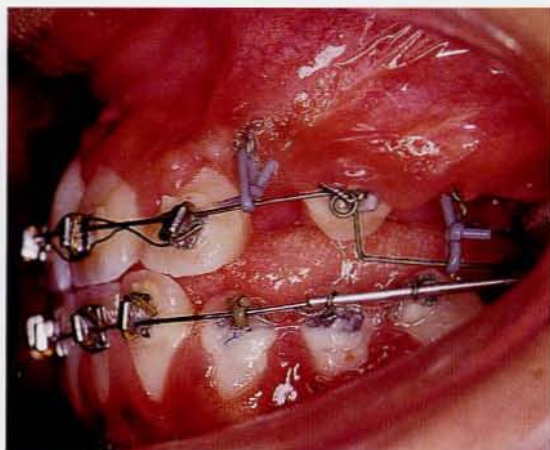
The buccal side pieces are now used as a rigid beam, from which elastic thread may be tied (Figs 9.14b,c) under pressure to the 'rolled up' pigtail ligatures of the unerupted premolar and canine teeth. Re-ligation will be needed at frequent intervals, because of the relatively poor range of action of the elastic thread. Alternatively, the Johnson-type archwire may be discarded in favour of a plain 0.018" or 0.020" archwire, stretching from molar to molar. Its long span, between lateral incisor and first molar, is flexible in the vertical plane, and the pigtail ligatures may be turned

over, to engage the wire under light extrusive tension (Figs 9.15a,b). Stage 4 is expected to be completed within 9–15 months (Fig. 9.16).

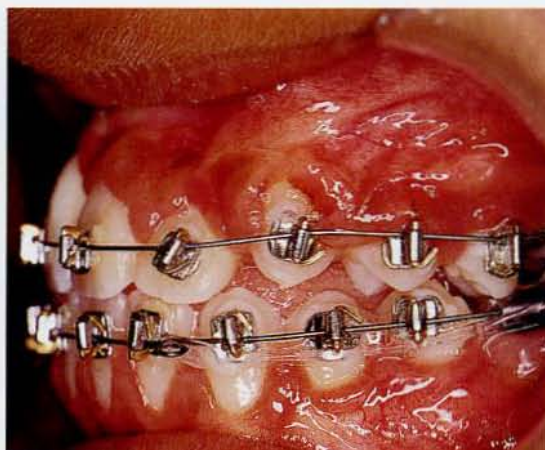
Stage 5: Correction of the axial orientation of the roots of the teeth

Orthodontics

Mesio-distal uprighting of the anterior teeth will have already occurred, if edgewise brackets have been used initially, although root-torqueing movements will usually need to



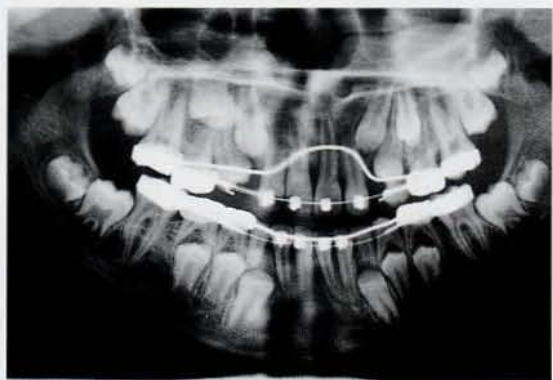
(a)



(b)

Figure 9.15

(a,b) The same patient as in Fig. 9.14: stages in the resolution of the impaction of the left side canines and premolars, using various types of mechanics.



(a)



(b)

Figure 9.16

The same patient as in Figs 9.14 and 9.15. (a) Panoramic view immediately prior to second surgical intervention (under local anaesthetic), in the mandibular arch only. (b) Panoramic view 5 months later, immediately following second surgical intervention in the maxillary arch (also under local anaesthetic).

await the use of a full rectangular arch. With the use of Begg brackets, levelling and torqueing auxiliaries may be used during stage 4, once the heavier wires are being used in the latter stages. However, given the amount of root displacement seen in these cases, it is most likely that stage 5 of the treatment will see these movements still being applied to the anterior teeth, while uprighting and rotating movements will need to be initiated in the premolar/canine regions, following the replacement of the eyelets with brackets (Fig. 9.17).

At this stage, the palatal and lingual heavy arches are no longer needed, and may be cut off with a high-speed diamond bur. In the various edgewise methods, the molar bands will now have to be removed in any case, and new bands adapted, with rectangular tubes. Molar expansion or rotation may now be performed, if desired.

TREATMENT EXPERIENCE

To date, 16 cleidocranial dysplasia patients have been treated or are still in the various stages of comprehensive orthodontic/surgical treatment at our centre (Figs 9.18 and 9.19) (Becker et al, 1997b). It is from their treatment that the Jerusalem approach (Becker et al, 1997a) has been formulated and refined over the years.

Of these cases, three had a total absence of supernumerary teeth, one of whom had a congenitally missing premolar. Seven patients had four supernumerary teeth or less and four others had 6, 8, 10 and 23 respectively. Treatment of the remaining case was initiated elsewhere, and information was not available for him. With the exception of those found in the incisor region, all other supernumerary teeth are recognizable supplemental teeth, similar to those adjacent to them. Thus supernumerary teeth in the canine and premolar regions are caniniform or premolariform. Barrel-shaped supernumerary teeth have been the only exception in our sample, and these have all been found in the maxillary central incisor region. The presence of supple-

mental teeth has been helpful in our choice of teeth for extraction, since a displaced tooth may be removed and the better-placed adjacent tooth aligned in its place, without regard to distinguishing which is the abnormal tooth.

Without exception, the dental age of our cases ranged from 2.5 to 4 years behind the chronological age. Spontaneously erupted first permanent molars have been seen in all but two cases, and these exhibited supernumerary molar teeth. Unlike other teeth, the permanent molars appear to erupt spontaneously in cleidocranial dysplasia, and it seemed reasonable to assume that, in the absence of these obstructions, the molars of these two patients would also have erupted normally. Following the removal of the supernumerary teeth, in both of these cases the unerupted molars were exposed and a surgical pack placed, to encourage healing by secondary intention and to maintain the patency of the exposure. The teeth erupted spontaneously after this preparatory surgical procedure, and both patients were then treated as per the above protocol.

A single erupted maxillary first premolar was present in three patients whose deciduous predecessor had had an apical abscess.

The shape of the well-developed permanent teeth, while clearly recognizable and classifiable into their different tooth types, showed labial concavities in the incisors, broad mesial and distal ridges on the labial and lingual aspects of both canines and incisors, and mesio-distally excessive and bucco-lingually narrow proportions of the lower second premolars. The roots of the successional teeth were relatively short, and their axial inclinations were not necessarily continuous with that of the crown, in both the mesio-distal and bucco-lingual planes. This created the need for periapical X-ray monitoring of the uprighting and torqueing movements of these teeth.

In the above treatment protocol, the ability to use intermaxillary vertical elastics on the previously impacted teeth was emphasized. Their value is seen in the enhancement of the eruptive forces to improve anchorage and to encourage vertical alveolar growth. Therefore



(a)



(d)



(b)



(e)



(c)



(f)

Figure 9.17

(a–c) A patient in the early part of stage 5. Note the severe bucco-lingual and mesio-distal displacement of roots of individual teeth. (d–f) Stage 5 close to completion.



(a)



(d)



(b)



(e)



(c)



(f)

Figure 9.18

The same patient as in Fig 9.17. (a–c) At the start of treatment. (d–f) At the completion of treatment. Note the tooth size discrepancy between the jaws.



(a)



(b)



(c)



(d)



(e)



(f)

Figure 9.19

(a-c) A patient before treatment. (d-f) At 1 year post-retention.

efficiency is not served by treating the mandibular anterior teeth before the maxillary anterior teeth, merely because there is a time lapse of a year or so between the normal eruption times of these teeth. The treatment of the anterior areas of both jaws should begin at the same time. Nevertheless, it is essential that the forces produced by these vertical 'up-and-down' elastics be kept within very minimal values, since the temptation exists to use elastics that are too small and too thick. Excessive extrusive forces will bring about rapid eruption, but the clinical crown length of the erupting teeth will be large, owing to relatively lesser generation of alveolar bone. The teeth will be very mobile, and may lose their vitality.

In the first surgical intervention, the aim is to remove all the supernumerary teeth, since these seem to be the principal factor in the displacement of the adjacent permanent teeth more deeply into basal bone. The continued presence of these extra teeth will prevent the teeth of the normal series from expressing what little eruptive potential they may have, and hence importance is attached to early removal. This is not felt to be the same for the deciduous teeth. Our experience has been that, when supernumerary teeth are not present in certain areas, the normal permanent teeth in those areas are not severely displaced, and, while they may still not erupt spontaneously, their development is fairly normal. Occasionally, their presence may stimulate the shedding of the deciduous predecessor, and they may, in time, erupt. For this reason, in those areas where supernumerary teeth are not found, deciduous teeth are not removed in the first surgical intervention.

Trauma to developing teeth has been shown to cause damage to both developing roots and the enamel of their completed crowns (Brin et al, 1984; Ben Bassat et al, 1985; Zilberman et al, 1986). Normal development and maximum eruption potential are probably best realized when the integrity of the dental follicles is maintained, until two-thirds to three-quarters of the root length has developed. For these reasons, the canine and premolar teeth are not exposed when the supernumerary teeth are removed in the first

surgical phase of the treatment.

Both in this text and elsewhere (Becker et al, 1983; Kohavi et al, 1984), we have been at pains to point out our opposition to the accepted and established practice of wide surgical exposure of unerupted teeth in normal cases with isolated impacted teeth (Lappin, 1951; Lewis, 1971; von der Heydt, 1975). Given the underdevelopment of the maxilla in the antero-posterior plane and of both jaws in the vertical plane in cleidocranial dysplasia (Kalliala and Taskinen, 1962; Zegarelli et al, 1978; Shafer et al, 1983), and the fact that a very large number of unerupted teeth are present within the bone and largely eliminating the spongiosum, the wide removal of the cortical plate (Smylski et al, 1974; Hall and Hyland, 1978; Richardson and Swinson 1987; Behlfelt, 1987) would appear to be wasteful and compromising.

In the Jerusalem approach, access to the teeth is gained by a minimal opening in the cortical plate, immediately overlying the teeth. The size of the opening is determined by two factors:

- (a) exposing a surface large enough to accommodate a small eyelet attachment;
- (b) enlarging this to the minimum size that will allow the surgeon to achieve haemostasis for long enough to allow the bonding procedure to take place in a contamination-free micro-environment.

There is no reason to remove further bone and certainly not to reduce the vertical height of the adjacent cortical plate. The complete surgical flaps are sutured back to close off the surgical field fully, and healing is by primary intention, which would appear to offer a healthier and more rapid period of healing and to promote a speedier and more generous response on the part of the alveolar bone (Laskin, 1985). The final periodontal status of the teeth will also be more normal (Becker et al, 1983; Kohavi et al, 1984).

Deeply displaced teeth may thus be drawn occlusally through the overlying bone, which offers no real resistance to the mechanically assisted eruptive force. New alveolar bone accompanies the erupting teeth as they progress towards the occlusal plane, in a

manner similar to that occurring with normal, unassisted eruption in the normal patient (Becker et al, 1983; Kohavi et al, 1984). This will enhance the vertical height of the alveolar processes of the two jaws, incidentally deepening the labial and lingual sulci and improving the overall facial proportions.

In the other two methods, the need to maintain patency of the exposure and visual contact with the unerupted teeth dictates that the bone level must be pared down to that of the deepest tooth. This clearly includes the reduction of both the lingual and buccal cortical plates to this level – and this in a patient whose alveolar processes are already of reduced height, because of the syndrome.

PATIENT VARIATION

Similarities are seen among all of the patients suffering from cleidocranial dysplasia, but there is a varying degree of expression of the various characteristic features of the disease, together with many other sporadic phenomena that have been reported to occur with the condition. Erupted permanent incisors are sometimes seen, and these may eliminate the need for the 'incisor-erupting' initial heavy archwire, in one or both arches. Instead, the treatment may begin with the levelling phase with the modified Johnson twin-wire arch.

Some patients make their appearance for the first time at an advanced dental age, when root apex closure has occurred in most of the erupted and unerupted teeth. Obviously, there is no developmental determinant to dividing the treatment into the above-mentioned stages, although it may still be advisable from a strictly mechanical point of view. It is difficult to design an appliance that may efficiently extrude teeth in several areas at the same time. Nevertheless, the inclusion of the canines with the anterior teeth may have some merit in these cases.

At the completion of all the treatment and the placement of retainers, new radiographs should be taken to check for the development of recurrent supernumerary teeth, which sometimes occurs in the 14–16-year-old



Figure 9.20

Panoramic radiograph of a patient 12 years after all appliances were removed. A newly developing supernumerary premolar tooth is noted.

patient (Fig. 9.20). At this point, any decision regarding the extraction of such teeth is strictly a surgical one (Becker et al, 1982; Becker and Shteyer, 1987). When such teeth are identified at this late stage, their extraction is no longer an orthodontic decision, since full alignment of the teeth has been achieved and suitable retention will prevent any adverse effects. Such factors as location and accessibility, incipient resorption of neighbouring erupted teeth, and cysts will all influence the surgeon regarding the necessity and timing of their extraction.

REFERENCES

- Becker A (1987) Periodontal splinting with multistrand wire following orthodontic realignment of migrated teeth: report of 38 cases. *Int J Adult Orthod Orthogn Surg* 2: 99–109.
- Becker A, Goultschin J (1984) The multistrand retainer and splint. *Am J Orthod* 81: 470–4.

- Becker A, Shochat S (1982) Submergence of a deciduous tooth, its ramifications on the dentition and treatment of the resulting malocclusion. *Am J Orthod* **81**: 240-4.
- Becker A, Shteyer A (1987) A surgical and orthodontic approach to the dentition in cleidocranial dysostosis. *Trans Eur Orthod Soc* **63**: 121 (abst).
- Becker A, Zilberman Y (1978) The palatally impacted canine: a new approach to its treatment. *Am J Orthod* **74**: 422-9.
- Becker A, Bimstein E, Shteyer A (1982) Interdisciplinary treatment of multiple unerupted supernumerary teeth. *Am J Orthod* **81**: 417-22.
- Becker A, Kohavi D, Zilberman Y (1983) Periodontal status following the alignment of palatally impacted canine teeth. *Am J Orthod* **84**: 332-6.
- Becker A, Lustmann J, Shteyer A (1997a) Cleidocranial dysplasia: part 1 - general principles of the orthodontic and surgical treatment modality. *Am J Orthod Dentofac Orthop* **111**: 28-33.
- Becker A, Shteyer A, Bimstein E, Lustmann J (1997b) Cleidocranial dysplasia: part 2 - a treatment protocol for the orthodontic and surgical modality. *Am J Orthod Dentofac Orthop* **111**: 173-83.
- Behlfelt K (1987) Cleido-cranial dysplasia: diagnosis and treatment concept. *Trans Eur Orthod Soc* **63**: 25 (abst).
- Ben Bassat Y, Brin I, Fuks A, Zilberman Y (1985) Effect of trauma to the primary incisors on permanent successors in different developmental stages. *Ped Dent* **7**: 37-4.
- Bixler D (1976) Hereditary disorders affecting cementum and the periodontal structures. In: *Oral Facial Genetics* (ed RE Stewart, GH Prescott), pp 282-4. Mosby, St Louis.
- Brin I, Ben Bassat Y, Fuks A, Zilberman Y (1984) Trauma to the primary incisors and its effect on the permanent incisors. *Ped Dent* **6**: 78-82.
- Cohen MM Jr (1976) Dysmorphic syndromes with craniofacial manifestations. In: *Oral Facial Genetics* (ed RE Stewart, GH Prescott), pp 566-7. Mosby, St Louis.
- Davies TM, Lewis DH, Gillbe GV (1987) The surgical and orthodontic management of unerupted teeth in cleidocranial dysostosis. *Br J Ortho* **14**: 43-7.
- Elomaa E, Elomaa M (1967) Orthodontic treatment of a case of cleidocranial dysostosis. *Suom Hammaslaak Toim* **67**: 139-51.
- Frame K, Evans RIW (1989) Progressive development of supernumerary teeth in cleidocranial dysplasia. *Br J Orthod* **16**: 103-6.
- Frommer HH, Lapeyrolerie FM (1964) Two case reports of cleidocranial dysostosis. *New York J Dent* **34**: 103-7.
- Gorlin RJ, Cohen MM Jr, Levin LS (1990) *Syndromes of the head and neck*, 3rd edn, pp 249-53. Oxford University Press, New York.
- Gron A (1962) Prediction of tooth emergence. *J Dent Res* **41**: 573-85.
- Hall RK, Hyland AL (1978) Combined surgical and orthodontic management of the oral abnormalities in children with cleidocranial dysplasia. *Int J Oral Surg* **7**: 267-73.
- Hitchin AD, Fairley JM (1974) Dental management in cleido-cranial dysostosis. *Br J Oral Surg* **12**: 46-55.
- Howe GL (1971) *Minor Oral Surgery*, 2nd edn, pp 135-7. Wright, Bristol.
- Johnson JE (1934) A new orthodontic mechanism: the twin wire alignment appliance. *Int J Orthod* **20**: 946-63.
- Kalliala E, Taskinen PJ (1962) Cleidocranial dystosis: report of 6 typical cases and 1 atypical case. *J Oral Surg* **15**: 808-22.
- Kelly E, Nakamoto RY (1974) Cleidocranial dysostosis - a prosthodontic problem. *J Pros Dent* **31**: 518-26.
- Kohavi D, Becker A, Zilberman Y (1984) Surgical exposure, orthodontic movement and final tooth position as factors in periodontal breakdown of treated palatally impacted canines. *Am J Orthod* **85**: 72-7.
- Lappin MM (1951) Practical management of

the impacted maxillary canine. *Am J Orthod* 37: 769-78.

Laskin D (1985) *Oral and Maxillofacial Surgery*, Vol 2, pp 44-7. Mosby, St Louis.

Lewis PD (1971) Preorthodontic surgery in the treatment of impacted canines. *Am J Orthod* 60: 382-97.

Miller R, Sakamoto E, Zell A et al (1978) Cleidocranial dysostosis. A multidisciplinary approach to treatment. *J Am Dent Assoc* 96: 296-300.

Muller EE (1967) Transplantation of teeth in cleidocranial dysostosis. In: *Oral Surgery: Transactions of the 2nd Congress of the International Association of Oral Surgeons* (ed E Husted, E Hjorting-Hansen), pp 375-9. Munksgaard, Copenhagen.

Oksala E, Fagerstrom G (1971) A two-stage sutotransplantation of 14 teeth in a patient with cleidocranial dysostosis. *Suom Hammasslaak Toim* 67: 333-8.

Probster L, Bachmann R, Weber H (1991) Custom-made resin-bonded attachments supporting a removable partial denture using the spark erosion technique: a case report. *Quintessence Int* 22: 349-54.

Richardson A, Swinson T (1987) Combined orthodontic and surgical approach to cleidocranial dysostosis. *Trans Eur Orthod Soc* 63: 23 (abst).

Ricketts RM (1981) Perspectives in the clinical application of cephalometrics. The first fifty years. *Angle Orthod* 51: 115-50.

Shafer WG, Hine MK, Levy BM (1983) *A Textbook of Oral Pathology*, 4th edn, pp 678-80. Saunders, Philadelphia.

Shepard ES (1961) *Technique and Treatment with the Twin-Wire Appliance*. Mosby, St Louis.

Smylski PT, Woodside DG, Harnett BE (1974) Surgical and orthodontic treatment of cleidocranial dysostosis. *Int J Oral Surg* 3: 380-5.

Seow WK, Hertzberg J (1995) Dental development and molar root length in children with cleidocranial dysplasia. *Pediatr Dent* 17: 101-5.

Stewart RE, Prescott GH (eds) (1976) *Oral Facial Genetics*. Mosby, St Louis.

Tachdjian MO (1990) *Pediatric Orthopedics*. 2nd edn, pp 840-4. Saunders, Philadelphia.

Trimble LD, West RA, McNeill RW (1982) Cleidocranial dysplasia: comprehensive treatment of the dentofacial abnormalities. *J Am Dent Assoc* 105: 661-6.

Vermette ME, Kokich VG, Kennedy DB (1995) Uncovering labially impacted teeth: apically repositioned flap and closed-eruption techniques. *Angle Orthod* 65: 23-32.

von der Heydt K (1975) The surgical uncovering and orthodontic positioning of unerupted maxillary canines. *Am J Orthod* 68: 256-76.

Weintraub GS, Yasilove IL (1978) Prosthodontic therapy for cleidocranial dysostosis. Report of a case. *J Am Dent Assoc* 96: 301-5.

Winther JE, Khan MW (1972) Cleidocranial dysostosis: report of 4 cases. *Dent Pract* 22: 215-19.

Yamamoto H, Sakae T, Davies JE (1989) Cleidocranial dysplasia: a light microscope, electron microscope and crystallographic study. *Oral Surg Oral Med Oral Path* 68: 195-200.

Zachrisson BU (1977) Clinical experience with direct-bonded orthodontic retainers. *Am J Orthod* 71: 440-8.

Zegarelli EV, Kutscher AH, Hyman GA (1978) *Diagnosis of Diseases of the Mouth and Jaws*, p 137. Lea & Febiger, Philadelphia.

Zilberman Y, Fuks A, Ben Bassat Y et al (1986) Effect of trauma to primary incisors on root development of their permanent successors. *Ped Dent* 8: 289-93.

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The Orthodontic Treatment of Impacted Teeth

Impacted teeth have provided an ongoing challenge to the dental profession, and many of its specialties have offered treatment modalities in widely differing styles. In the long-term, it has come to be recognized that superior results are obtainable by the orthodontic/surgical modality. There is, however, a considerable difference of opinion between these two specialties as to which procedures should be carried out first and to what lengths each should be pursued.

This text proposes ways in which difficulties posed by impactions may be overcome with an integrated orthodontic/surgical strategy. It emphasizes the importance of determining an appropriate directional traction force and presents ways of effecting this with the use of different types of orthodontic auxiliaries. The relationship between these factors and a favourable prognosis of the completed treatment result is stressed.

A range of issues affecting impacted teeth, including an extensive review of their diagnostic and management procedures, and aetiology is presented.

Contents • General principles • Radiographic methods • Surgical exposure • Treatment strategy • Maxillary central incisors • Palatally impacted canines • Other single teeth • Impacted teeth in the adult • Cleidocranial dysplasia

With over 400 colour and black-and-white photographs

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